ALLEN-BRADLEY
A ROCKWELL INTERNATIONAL COMPANY

User's Manual

Bulletin 2804
Smart Linear Sensor
(Cat. No. 2804-SLS1, -SLS2)

40062-209-01(B)

Catalog No. 2804-ND001 Series B

Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. "Application Considerations for Solid-State Controls" (Publication SGI-1.1) describes some important differences between solid-state equipment and hard wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Allen-Bradley Company be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Allen-Bradley Company cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Allen-Bradley Company with respect to use of information, circuits, equipment, or software described in this manual.

Reproduction of the contents of this manual, in whole or in part, without written permission of the Allen-Bradley Company is prohibited.

© 1991 Allen-Bradley Company

Table of Contents

Chapter	Title	Page
1	**Introduction: Smart Linear Sensor**	
	Chapter Objective	1-1
	User Manual Objective	1-1
	User Experience	1-1
	Smart Linear Sensor: Product Overview	1-2
	SLS Hardware	1-3
	SLS Housing	1-3
	Lens	1-5
	Power Supplies	1-5
	Cables	1-5
	Optional Configuration Support Software	1-6
2	**SLS Access Panel**	
	Chapter Objective	2-1
	SLS Access Panel: Overview	2-1
	Configuration Switches	2-1
	Setpoint Adjustment Controls	2-6
	LEDs	2-7
3	**Hardware Connection and Powerup Check**	
	Chapter Objective	3-1
	Cable Connections	3-1
	Power Supply: 2801-P3, P4	3-4
	Connecting to AC Power Source	3-4
	Connecting DC Cable	3-5
	Powerup Check	3-6
4	**SLS Quick-Start Operation**	
	Chapter Objective	4-1
	Quick-Start Setup and Checkout	4-1
	Staging SLS	4-3
	Focusing and Aiming SLS	4-4
	Setting Configuration Switches	4-5
	Performing Teach Operation	4-8
	Performing Run Operation	4-9

Chapter	Title	Page
5	**SLS Analysis Functions**	
	Chapter Objective	5-1
	Analysis Functions	5-1
	1-D Spatial Measurement	5-2
	Object Width Measurement	5-7
	Object Void Measurement	5-13
	Largest Object Width	5-16
	1-D Object Recognition	5-18
	Included-Object Texture Recognition	5-24
	Full-Field Texture Recognition	5-31
	Binary Object Size, Binary Object Count	5-37
	Parts Counting	5-38
	Teach Function	5-39
	Run Function	5-40
	2-D Object Size	5-45
	Teach Function	5-46
	Run Function	5-47
6	**SLS Site Installation: Requirements and Procedures**	
	Chapter Objective	6-1
	Site Preparation Requirements	6-1
	Staging and Installation Procedures	6-1
	Determining FOV Width	6-1
	Focusing the SLS	6-2
	Positioning "Ideal" Object in FOV	6-3
	Mounting and Positioning SLS	6-3
	Mounting and Positioning Light Source	6-4
	SLS Connection Procedures	6-4
	Connecting J1 Cable	6-4
	Connecting J2 Cable	6-5
	Connecting J3 Cable	6-6
	Before Applying AC Power	6-6
	Performing Powerup Check	6-6
	Fine Tuning SLS Aim	6-7
	Setpoint Adjustment Controls	2-6
	LEDs	2-7

Appendix	Title
Appendix A	**Definition of Terms**

Appendix	Title	Page
Appendix B	**Reference Information**	
	Appendix Objective	B-1
	Using Appendix B	B-1
	Focusing SLS	B-1
	Exposure Time, Cycle Time, and Lighting Compensation	B-2
	Speed vs Resolution	B-4
	Side View SLS: 2804-SLS2	B-4
	Lens Filter: Maintenance and Replacement	B-5
	I/O Connections	B-7
	Mounting Brackets	B-8
	Trigger Input Modes	B-8
	Binary Threshold, Background Light Probe	B-9
	Burst Acquisition Mode	B-9
	Set Point Methods	B-10
	Invert Discrete Output B	B-11
	Disable Lighting Compensation	B-11
	Power Loss Recovery	B-11
	Connector Covers on J2 and J3	B-12
	Grounding	B-12

Figure	Title	Page
	List of Figures	
1.1	SLS Components and Connections	1-2
1.2	SLS Models: Front-View Lens and Side-View Lens	1-3
1.3	SLS: Access Panel Cover Installed and Removed	1-4
2.1	Configuration Switches	2-1
2.2	Setpoint Adjustment Controls	2-6
2.3	LEDs: Operational Status Functions	2-7
3.1	SLS Connectors: Side View	3-1
3.2	SLS Connectors: Rear View	3-1
3.3	Cable Connectors and Wire Color Codes	3-2
3.4	AC Terminal Block Wiring	3-4
3.5	DC Terminal Block Wiring	3-5
3.6	LEDs: Diagnostic Status Functions	3-6
4.1	Aiming Target	4-2
4.2	SLS Staging	4-3
5.1	Field of View Orientation	5-1
6.1	Standoff Distance From Inspected Object	6-2
6.2	FOV Orientation and Inspection Direction	6-3
B.1	Measuring Distance to Inspected Object	B-1
B.2	Lens Focusing Details	B-2
B.3	Timing Relationships	B-3
B.4	Side-View SLS: 2804-SLS2	B-4

Figure	Title	Page
	List of Figures *(continued)*	
B.5	Exploded View of Lens, Filter, and O-Ring	B-5
B.6	O-Ring Installation	B-6
B.7	I/O Connections	B-7
B.8	Using Both Set Points on One Result	B-10

Table	Title	Page
	List of Tables	
2.1	Analysis Functions: Objectives and Switch Settings	2-5
3.1	SLS Connectors: Pin Functions and Wire Color Codes	3-2
3.2	Electrical Specifications for Pin Functions	3-3
3.3	Powerup Error Indications	3-7
6.1	Standoff Distance Determination	6-2
6.2	J1 Specifications: Strobe and Analog Outputs	6-4
6.3	J2 Specifications: Trigger Input and Discrete Outputs	6-5
6.4	J3 Specifications: RS-232 I/O and +24 VDC Outputs	6-6
B.1	High Resolution vs High Speed Mode	B-4

Chapter 1 Introduction: Smart Linear Sensor

Chapter Objective

The objectives of this chapter are to introduce you to the Allen-Bradley 2804-SLS1, SLS2 Smart Linear Sensor and to explain the overall objective of this manual.

User Manual Objective

The objective of the Smart Linear Sensor User Manual is to provide the information and procedures you need to prepare your Smart Linear Sensor (SLS) for inspection applications.

The user manual is intended to complement the instruction sheet included with the SLS. The instruction sheet may be sufficient for those who have experience with machine vision, or whose applications are fairly simple.

Chapter 2 introduces you to the SLS access panel.

Chapter 3 steps you through the procedures for connecting the signal and power cables, powering up the SLS, and checking the SLS operational status.

Chapter 4 steps you through a "quick-start" procedure, which uses a simple example to show you the basic steps for setting up and using the SLS. At the same time, you can check the SLS in operation.

Chapter 5 describes the analysis functions that are available to configure the SLS for inspection applications.

Where appropriate, the user manual provides one or more simple examples to help you understand the concepts involved in a particular feature or function. Following an example, the user manual provides the step-by-step instructions for configuring the feature or function.

User Experience

This manual and the SLS are intended for persons with no vision training or experience, but who have some familiarity with the installation and use of industrial sensing devices such as photoelectric switches and proximity switches. It is assumed that the user is familiar with the intended application, and that the application is within the capabilities of the SLS.

Smart Linear Sensor: Product Overview

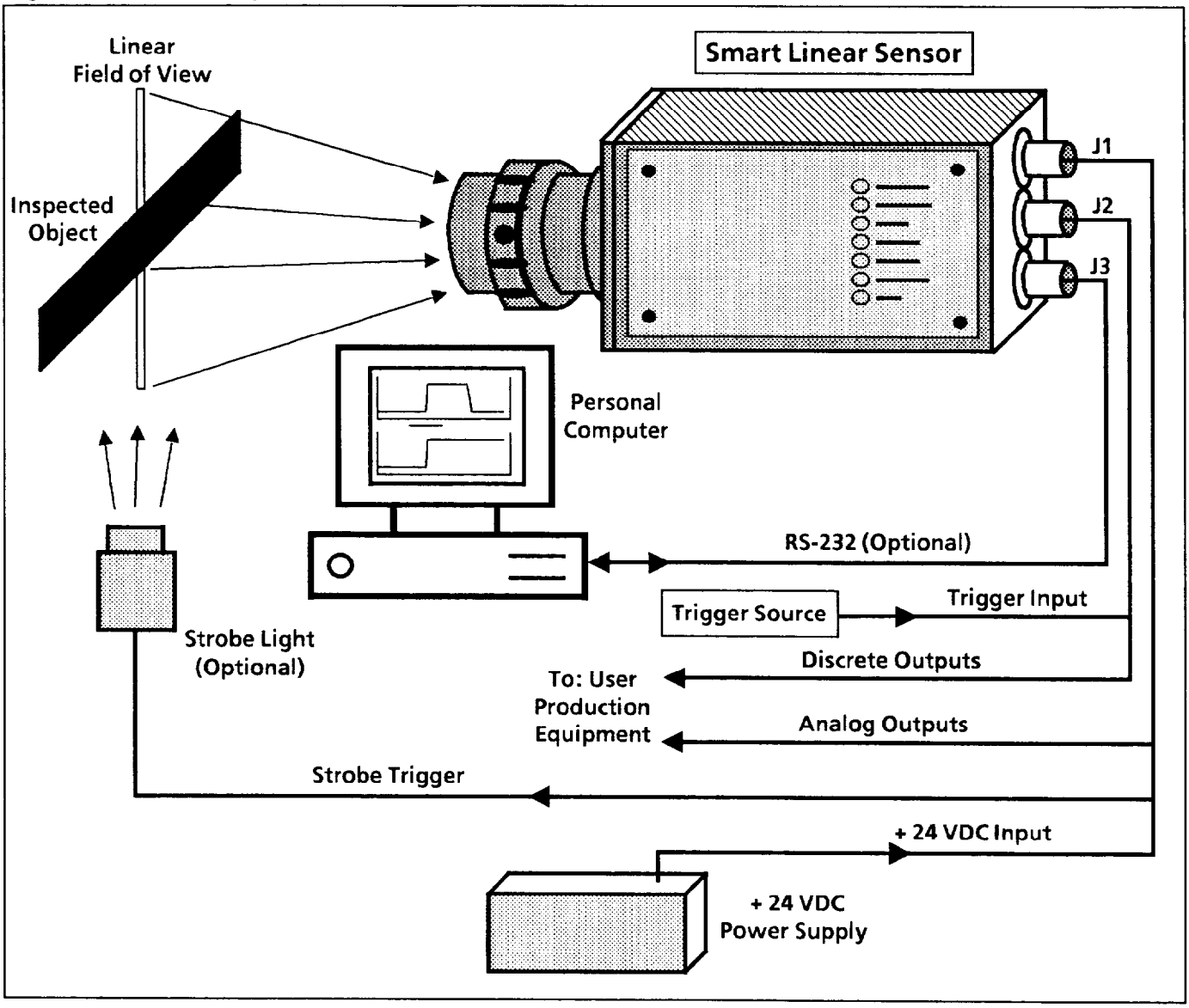
The SLS is an easy-to-configure, high performance machine vision system that can be used for a variety of process control and manufacturing inspection applications.

The SLS and lens are housed in a NEMA-4X compatible package. Three cable connectors are provided for connecting DC power and signal lines to the SLS. The SLS can be mounted using an aluminum bracket (Bulletin 880-N12 Photoelectric Switch mounting bracket) or a three-axis stainless steel bracket (Catalog No. 2804-BR1). The 2804-BR1 is required to maintain the NEMA-4X rating.

An optional SLS Configuration Support Software package can be used to upload and download SLS configurations, and can also monitor SLS operations and accumulate statistics.

Figure 1.1 identifies, in symbolic form, the basic SLS components and shows the connections between these components

Figure 1.1 SLS Components and Connections



SLS Hardware

The basic SLS hardware includes the sensor, lens, mounting bracket, power supply, and cables. The lens, mounting bracket, and power supply are ordered separately. Connecting cables are provided by the user.

SLS Housing

The SLS is available in two models that are identical except for the lens:

- Catalog No. 2804-SLS1: Front-view lens.
- Catalog No. 2804-SLS2: Side-view lens.

Figure 1.2 shows the two SLS models.

Figure 1.2 SLS Models: Front-View Lens and Side-View Lens

2804-SLS1: Front-View Lens

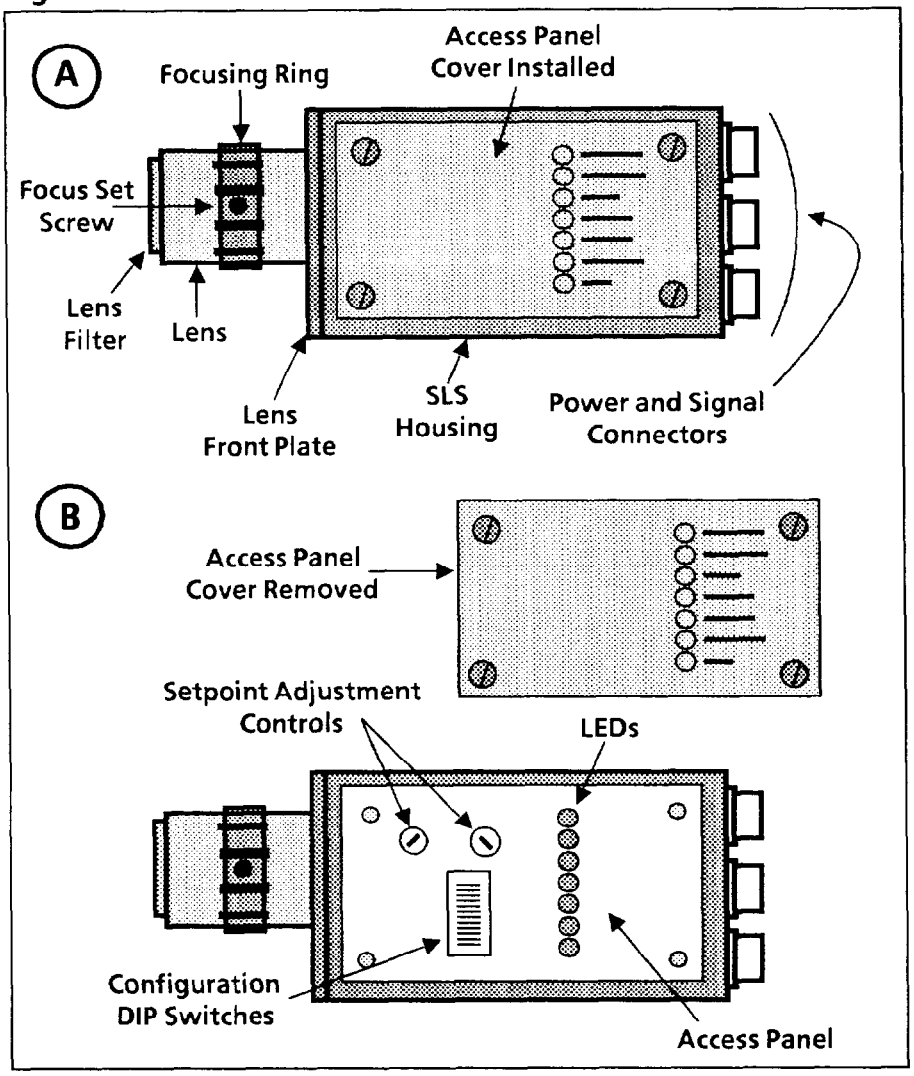
2804-SLS2: Side-View Lens

SLS Housing (continued)

The SLS electronics are completely contained in a NEMA-4X compatible housing. The SLS lens is in a separate unit attached to the front of the SLS housing. An access panel is under a cover on the side of the housing.

Figure 1.3A is a side view of the SLS showing the access panel cover in place. Figure 1.3B is the same view showing the access panel cover removed.

Figure 1.3 SLS: Access Panel Cover Installed and Removed



The access panel contains the configuration switches, setpoint adjustment controls, and LEDs. The panel access cover is secured by four slotted screws (#4-40 x 3/8"). It uses a neoprene seal to maintain the NEMA-4X rating.

SLS Housing (continued)

The configuration switches are arranged in a 12-switch DIP package. These switches select the analysis parameters and functions for an inspection application.

The setpoint adjustment controls set the switching points for the discrete outputs.

The LEDs indicate the operating status of the SLS and the discrete outputs.

Lens

Allen-Bradley provides two lenses for the SLS:

- Catalog No. 2804-NL1: A standard lens (focal length, 35mm; viewing angle, approximately 19°).
- Catalog No. 2804-NL2: A wide angle lens (focal length, 28mm; viewing angle, approximately 30°).

These lenses are designed especially for the SLS.

Power Supplies

Allen-Bradley provides two +24 VDC power supplies for the SLS:

- Catalog No. 2801-P3: Provides +24 VDC @ 1.6A; requires 85-135 VAC @ 47 to 63Hz.
- Catalog No. 2801-P4: Provides +24 VDC @ 1.6A; requires 170 to 270 VAC @ 47 to 63Hz.

The SLS can also operate from any NEMA/NEC Class 2 power supply that provides 20 to 28 VDC @ 20W.

Cables

The SLS uses standard Brad-Harrison Micro-Change®, or equivalent, connecting cables for signal interfacing. The specific cables to use are shown in the following table:

Brad-Harrison Cables

Cable Length	SLS Connectors/Cable Part Numbers		
	J1	J2	J3
6 Feet (1.8m)	70632	70621	70432
12 Feet (3.7m)	70634	70623	70434
20 Feet (6.1m)	70635	70624	70435

Cables (continued)

Allen-Bradley does not supply the connecting cables for the SLS; however, these cables are available from your local Allen-Bradley photoswitch distributor or a Brad-Harrison cable distributor.

Optional Configuration Support Software

The optional SLS Configuration Support Software, Catalog No. 2804-SW1, is a menu-driven, IBM PC-compatible application program that enables you to store (upload) and retrieve (download) SLS application configurations using your personal computer (PC). In addition, it enables you to monitor SLS inspection operations, and it can accumulate and log runtime statistics.

The software contains online "help" messages. At any point in the program, you can call up a "help" screen to learn more about the corresponding program functions and requirements.

Allen-Bradley provides the support software package as Catalog No. 2804-SW1. This includes the following items:

- Two 5-1/4-inch diskettes and one 3-1/2-inch floppy diskette containing the support software.
- One 12-foot (3.7m) connecting cable, Catalog No. 2804-CSC1, for attachment to your PC's serial port.
- One User's Manual for the support software, Catalog No. 2804-ND002.

  The user's manual provides information for installing the support software in your PC and using it.

In order to use the support software, your PC must have the following *minimum* configuration:

- An IBM PC/AT/XT/PS2 or compatible PC with at least 475K-bytes of free memory.
- MS-DOS 2.1, or later.
- Disk drive systems:
  - Two 5-1/4-inch floppy disk drives (any density), *or*
  - One 3-1/2-inch floppy disk drives (any density), *or*
  - One hard disk drive (any size) *and* one floppy disk drive.
- An RS-232 communication port.
- A Catalog No. 2804-CSC1 cable to connect the SLS to the PC (supplied with the support software).
- A video monitor.
- A graphics display adapter.

Optional Configuration Support Software (continued)

Here is a list of *recommended* hardware:

- An IBM AT or compatible PC – A PC based on the 80286, 80386, or 80486 microprocessor operates much faster than an 8088-based PC.
- A hard disk drive – This enables you to store the SLS Configuration Support Software and operate the software faster and more efficiently.
- A math coprocessor – This enables your PC to perform mathematical calculations faster than the same PC *without* a coprocessor.
- An EGA or VGA graphics adapter – This enables your PC to display images in color with greater resolution.
- A printer – This enables you to print hard copies of reports.

Chapter 2 SLS Access Panel

Chapter Objective

The objective of this chapter is to describe the functions of the SLS access panel.

SLS Access Panel: Overview

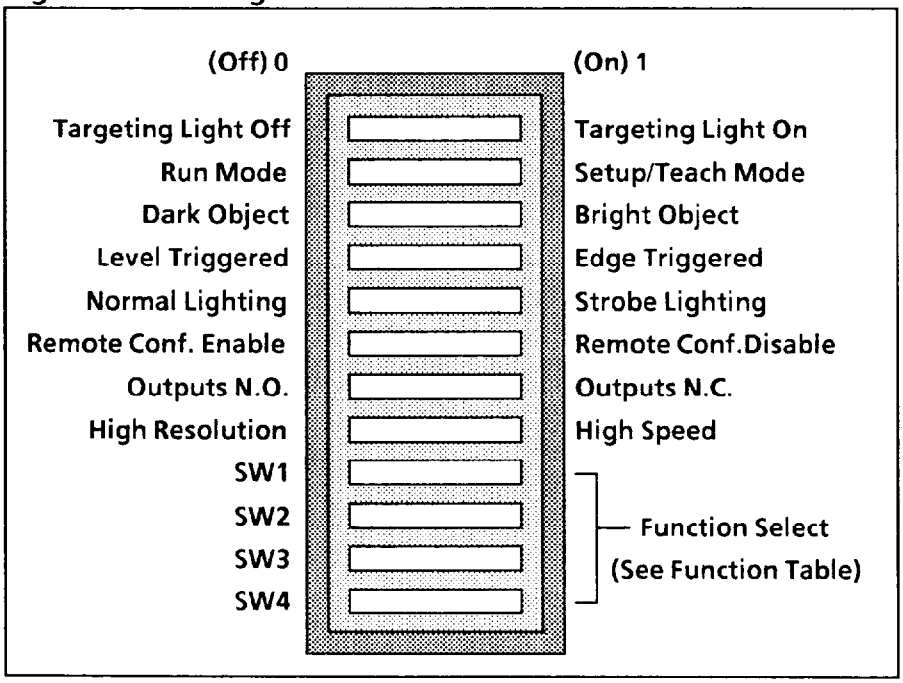
As shown in Chapter 1, the SLS access panel is located under a protective cover on one side of the SLS housing. Here are the components included on the access panel :

- *Configuration Switches* – These are 12 switches in a dual-inline-pack (DIP). They select the operating parameters and inspection function for your SLS application(s).
- *Setpoint Adjustment Controls* – These are two screwdriver-adjustable controls. They set the point at which inspection results change the state of the discrete outputs.
- *LEDs* – These are seven LEDs. They signify the status of a number of parameters during SLS operation.

Configuration Switches

As noted above, the configuration switches are arranged in a 12-switch DIP package on the access panel. Figure 2.1 shows the functions assigned to each of the 12 switches.

Figure 2.1 Configuration Switches



These switch functions are printed on the nameplate inside the access panel.

Configuration Switches (continued)

Each switch can be "rocked" to the left or right with a small screwdriver or similar instrument. *Left* corresponds to the "(Off) 0" position; *right* corresponds to the "(On) 1" position. Thus, rocking a switch to the left selects the function on the left side, and vice versa.

Here is a description of each configuration switch function:

- **Targeting Light Off, Targeting Light On** – This switch turns the targeting light *on* and *off*.

  The targeting light emits a line of light that shows you where the SLS is *aimed*. This line indicates the location of the SLS field of view (FOV). Thus, by aiming the targeting light at the inspected object, you can align the FOV with that object.

  Note that while the targeting light is *on*, the SLS suspends all image processing.

  Since the targeting light is designed for intermittant use, the SLS turns the light *off* after it has been *on* for two minutes, or when the lens head gets too warm. After the lens head cools, you can turn the light *on* again by setting the switch to *off*, then *on*.

  NOTE: You should not attempt to *focus* the SLS using the targeting light, since it may cause an incorrect focus.

- **Run Mode, Setup/Teach Mode** – When you set this switch to *setup/teach mode*, and position an "ideal" object in the FOV, the SLS calibrates ("learns") the internal automatic lighting compensation function. This process requires the SLS to acquire several images; thus, it takes only a few seconds if the SLS is operating at maximum speed.

  When you set the switch to *run mode*, the calibration process terminates, and the SLS *stores* the "learned" configuration parameters,

  After you set the switch to *run mode*, the SLS begins performing its normal inspection operations.

  NOTE: If you attempt to operate certain analysis functions in the *run mode* without first using the *setup/teach* mode, the Fault/Error LED turns *on*.

- **Dark Object, Bright Object** – Set this switch to *dark object* when the inspected objects are darker than the background. Conversely, set the switch to *bright object* when the inspected objects are brighter than the background.

  NOTE: The terms "dark" and "bright" refer to the *relative* light intensity or contrast (*not color*) between the object and its background. If the contrast is not great enough for the analysis function to perform reliably, the Low Contrast LED turns *on*.

Configuration Switches *(continued)*

- **Level Triggered Mode, Edge Triggered Mode** – When you set this switch to *level triggered mode*, and the external trigger input is either *low* or *not connected*, the SLS acquires images continuously at maximum speed using an internal trigger source. (The maximum speed depends on the cycle time of the selected analysis function, the exposure time, and the setting of the *High Resolution, High Speed* switch.)

  When the trigger input goes *high*, the SLS discontinues image acquisition.

  When you set this switch to *edge triggered mode*, the SLS acquires one image with each high-to-low transition of the external trigger signal, up to its maximum rated speed.

  The color of the Duty Cycle LED indicates the trigger signal repetition rate. Thus, *red* indicates that the SLS is waiting for a trigger, "*orange*" indicates triggers arriving at less than the maximum rate, and *green* indicates triggers arriving at or close to the maximum allowable rate.

  NOTE: Be certain that external trigger signals do not recur at *shorter* intervals than the cycle time of the selected analysis function; otherwise, the SLS will not process all of them. (The Duty Cycle LED turns "orange" if the interval is *much* shorter than the cycle time.)

- **Normal Lighting, Strobe Lighting** – Set this switch to *normal lighting* mode if you are using *continuous* lighting to illuminate the inspected objects. In this mode, the exposure time varies according to the intensity of the light; thus the lighting compensation is effective over a wide range of light intensities.

  Set the switch to *strobe lighting* if you are using a strobe light to illuminate the objects. In this mode, the exposure time is fixed at 0.5mSec.

- **Remote Conf. Enable, Remote Conf. Disable** – Set this switch to *remote configuration enable* to enable a personal computer (PC), using the optional SLS Configuration Support Software, to download a stored configuration to the SLS and monitor SLS operations. In this mode, the configuration and setpoint settings specified in the stored configuration can *override* the physical switch and control settings on the SLS and control its operation.

  Set this switch to *remote configuration disable* to inhibit the PC from downloading a configuration to the SLS, but still allow the PC to monitor SLS operations. In this mode, the physical switch and control settings in the SLS control its operation.

Configuration Switches (continued)

- **Outputs N.O., Outputs N.C.** – This switch determines the operation of discrete output lines A and B relative to the settings of their corresponding setpoint adjustment controls. ("N.O." means "normally open," and "N.C." means "normally closed.")

  When you set this switch to *Outputs N.O.*, discrete output line A (or B) "opens" if an inspection "result" (such as object width) is *lower* than the setting of setpoint control A (or B). Conversely, the output line "closes" when the inspection result is *higher.*

  For example, if an inspection result, such as object width, is 40%, and setpoint control A is set to 50%, discrete output line A "opens," and current *cannot* flow in the external circuit.

  NOTE: In the *Output N.O.* mode, the output line *defaults* to "open" during powerup and whenever certain types of errors occur.

  When you set this switch to *Outputs N.C.*, discrete output line A (or B) "close" if an inspection "result" (such as first edge) is *lower* than the setting of setpoint control A (or B). Conversely, the output line "opens" when the inspection result is *higher.*

  For example, if an inspection result, such as first edge, is 20%, and setpoint control A is set to 40%, discrete output line A "closes," and current *can* flow in the external circuit.

  NOTE: In the *Output N.C.* mode, the output line *defaults* to "closed" during powerup and whenever certain types of errors occur.

- **High Resolution, High Speed** – When you set this switch to *high resolution*, the SLS produces the highest possible image resolution at some sacrifice in operating speed. Use high resolution for most applications.

  When you set the switch to *high speed*, the SLS produces the highest possible operating speed at some sacrifice in image resolution. Select this mode when the *high resolution* mode is not fast enough for your application.

- **SW1, SW2, SW3, SW4** – These four switches select the SLS analysis function. The specific function selected depends on the combined settings of the four switches.

  Table 2.1, below, lists the analysis functions by name, function objective, and specific switch settings.

Configuration Switches
(continued)

Table 2.1 Analysis Functions: Objectives and Switch Settings

Analysis Function Name	Function Objectives	SW1	SW2	SW3	SW4
1-D Spatial Measurement	Locate position of first and last edges of object.	0 (Off)	0 (Off)	0 (Off)	0 (Off)
Object Width Measurement	Measure width of object. Find center position of object.	0 (Off)	0 (Off)	0 (Off)	1 (On)
Object Void Measurement	Measure width of object. Measure cumulative total of "voids" within object.	0 (Off)	0 (Off)	1 (On)	0 (Off)
Largest Object Width (Series B SLS only.)	Measure width of largest object. Find center position of object.	0 (Off)	0 (Off)	1 (On)	1 (On)
1-D Object Recognition	Determine percentage of match to "learned" reference object. Measure object width.	0 (Off)	1 (On)	0 (Off)	0 (Off)
Included-object Texture Recognition	Determine percentage of match to "learned" reference object. Measure object width.	0 (Off)	1 (On)	0 (Off)	1 (On)
Full-field Texture Recognition	Determine percentage of match to "learned" reference object.	0 (Off)	1 (On)	1 (On)	0 (Off)
Binary Object Size (Series B SLS only. Can be used only with SLS Configuration Support Software.)	Use binary thresholding to identify objects and measure cumulative object size.	0 (Off)	1 (On)	1 (On)	1 (On)
Binary Object Count (Series B SLS only. Can be used only with SLS Configuration Support Software.)	Use binary thresholding to identify and count objects in FOV and measure object size.	1 (On)	0 (Off)	0 (Off)	0 (Off)
Null Function 1	N/A	1 (On)	0 (Off)	0 (Off)	1 (On)
Parts Counting Teach	"Learn" reference object and number of objects to count.	1 (On)	0 (Off)	1 (On)	0 (Off)
Parts Counting Run	Count objects.	1 (On)	0 (Off)	1 (On)	1 (On)
2-D Object Size Teach	"Learn" reference object.	1 (On)	1 (On)	0 (Off)	0 (Off)
2-D Object Size Run	Measure relative 2-D size of object.	1 (On)	1 (On)	0 (Off)	1 (On)
Null Function 2	N/A	1 (On)	1 (On)	1 (On)	0 (Off)
Null Function 3	N/A	1 (On)	1 (On)	1 (On)	1 (On)

Note that 16 different switch settings are possible; however, only 13 are currently used.

Chapter 5, *SLS Analysis Functions*, explains the 13 analysis functions in greater detail.

Setpoint Adjustment Controls

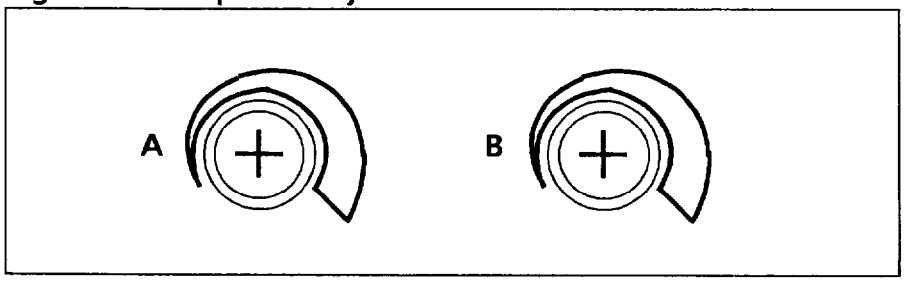
The setpoint adjustment controls determine the switching points for the discrete outputs. These are the points at which the discrete outputs "open" or "close" (according to the setting of the *Outputs N.O., Outputs N.C.* switch). Setpoint controls A and B determine the switching points for discrete outputs A and B.

Inspection "results" are expressed as percentages from 0% to 100%. For example, a one-dimensional spatial measurement result (that is, an *edge location*) can range from one side of the field of view (0% of FOV) to the other side (100% of FOV). Similarly, an object width measurement result can range from very narrow (greater than 0% of FOV) to very wide (less than 100% of FOV).

You can adjust a setpoint control to switch the corresponding discrete output at any point from 0% and 100%.

In Figure 2.2, the circular "wedge" shape indicates that turning a setpoint control clockwise (CW) increases the percentage of measurement range, and vice versa.

Figure 2.2 Setpoint Adjustment Controls



Here's an example: Suppose that you've configured the SLS to perform one-dimensional spatial measurements. Specifically, you're interested in monitoring the location of the *first* edge of an object. If the edge moves beyond the 40% of FOV point, you want an alarm to be activated

Suppose further that you've selected the *Outputs N.O.* mode for the discrete outputs.

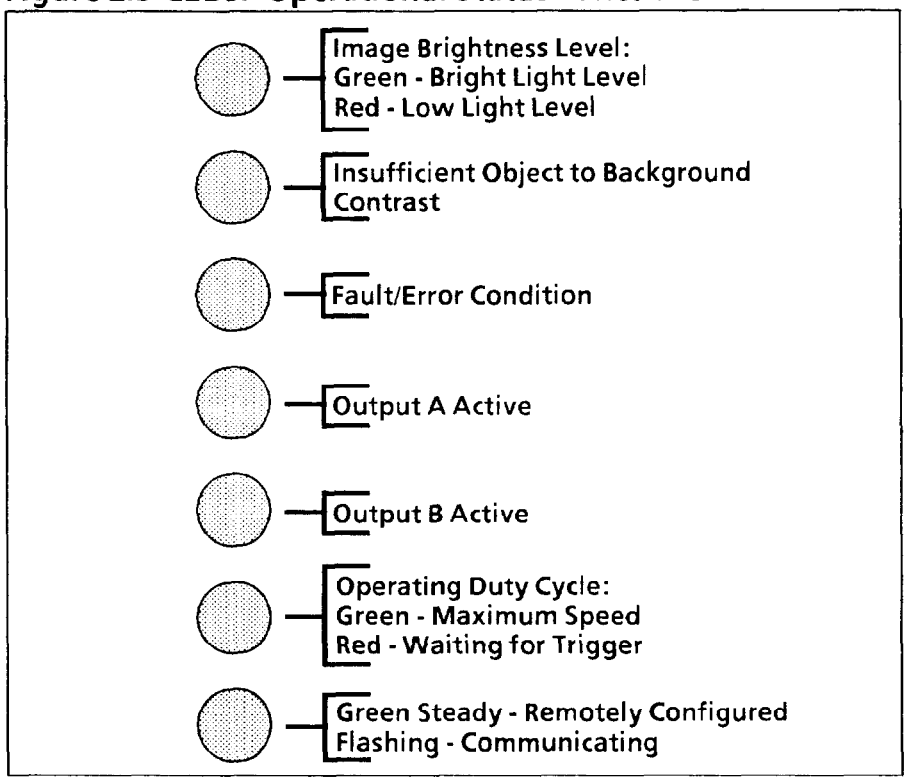
The SLS sends first edge "results" to discrete output A. In this example, you want discrete output A to remain "open" so long as the first edge location does *not* extend beyond the 40% point, and "close" if the edge extends beyond that point.

To accomplish this, you would adjust setpoint control A so that discrete output A closes when the edge location passes the 40% point. In a *practical* situation, you could perform that adjustment by moving the object's edge to (or just beyond) the 40% point, then adjusting control A *slowly* (to avoid overshooting), until output A closes. When you move the edge back below the 40% point, output A should open.

LEDs

The seven LEDs signify the operating status of the sensor. Figure 2.3 shows the LEDs and the labels as they appear on the access panel nameplate:

Figure 2.3 LEDs: Operational Status Functions



Here is a brief explanation of the labels alongside each LED:

- **Image Brightness Level** – Solid green indicates that the image is bright enough for the SLS to use a short exposure time. Solid red indicates that the image is so dim that the SLS must use a long exposure time. A mixture of red and green ("orange") indicates that the image is somewhere between bright and dim.

  In practice, the image should be bright enough so that the Image Brightness LED ranges from "orange" to green.

- **Insufficient Object Background Contrast** – When it is *on* (red), this LED indicates that the contrast between the object to be inspected and its background are not sufficient for the SLS to inspect the object. When the LED is *off*, the contrast is sufficient.

LEDs (Continued)

- **Fault/Error Condition** – When it is *on* (red), this LED indicates a lighting compensation error, a configuration error, or a changed switch setting while the SLS operates under the control of a downloaded configuration. (Chapter 3, *Hardware Connection and Powerup Check*, explains these conditions in more detail.) Normally, the LED is *off*.
- **Output A Active, Output B Active** – When one of these LEDs is *on* (yellow), it indicates that the corresponding discrete output is *closed* ("active"); that is, current *can* flow in the circuit to which the output is connected. Conversely, when the LED is *off*, it indicates that the discrete output is "open," and current *cannot* flow.

  NOTE: The term "Active" always refers to the LED being *on* and the output *closed*.
- **Operating Duty Cycle** – When it is green, this LED indicates that the SLS is operating at or near its maximum rated speed. When it is red, the LED indicates that the SLS is waiting for a trigger signal. When it is some shade of "orange," the LED indicates that the SLS is operating at less than its maximum rated speed.
- **Communication** – When it is *on* (green), this LED indicates all of the following conditions:
  - The remote configuration switch is set to *enable*.
  - The SLS is using a configuration downloaded from the optional SLS Configuration Support Software.
  - The SLS is controlled by the settings specified in the downloaded configuration.
  - The SLS is ignoring the physical switch settings.

  When it flashes briefly, the LED indicates that communication activity is taking place between the SLS and the PC.

  When it is *off*, the LED indicates that the SLS is controlled by its physical switch and control settings.

For additional details about the SLS support software, refer to the SLS Configuration Support Software User's Manual, Catalog No. 2804-ND002.

Chapter 3 Hardware Connection and Powerup Check

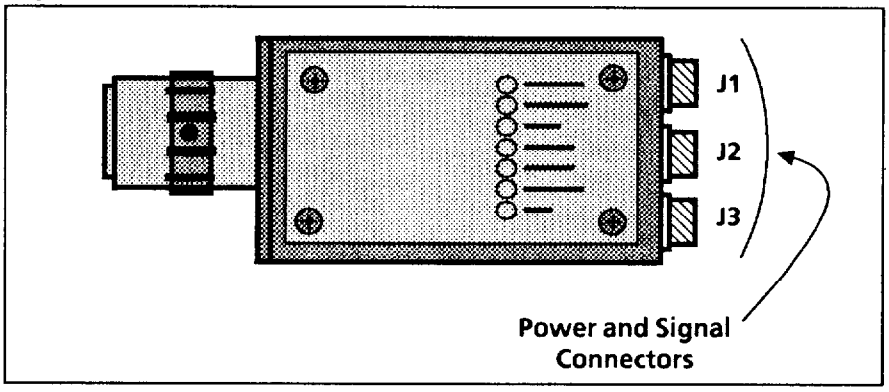
Chapter Objective

The objective of this chapter is to show you how to connect the SLS to the power supply and I/O devices, and perform a powerup check.

Cable Connections

The SLS connects to the power supply and all I/O devices through three connectors on the back of the case, labeled J1, J2, and J3. They are arranged as shown in Figure 3.1.

Figure 3.1 SLS Connectors: Side View



J1 is a 5-pin male connector, J2 is a 5-pin female connector, and J3 is a 4-pin male connector. Figure 3.2 shows the connectors as they appear from the rear of the SLS.

Figure 3.2 SLS Connectors: Rear View

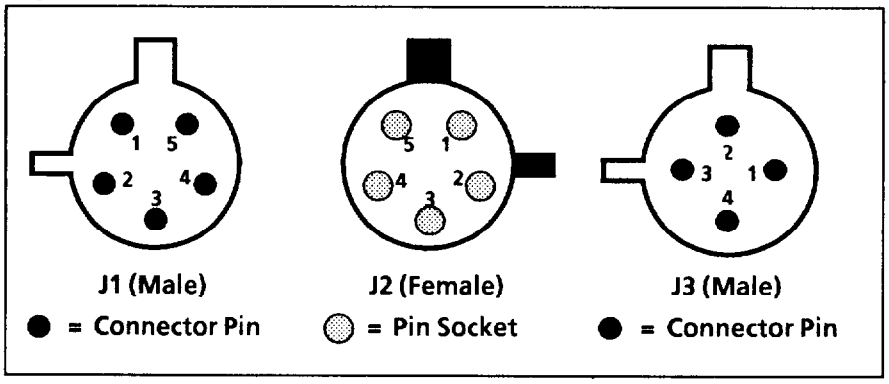


Figure 3.2 shows the pin numbering on the three connectors. The actual orientations of the connectors on your SLS may be *rotated* from the orientations shown in the figure.

Cable Connections (continued)

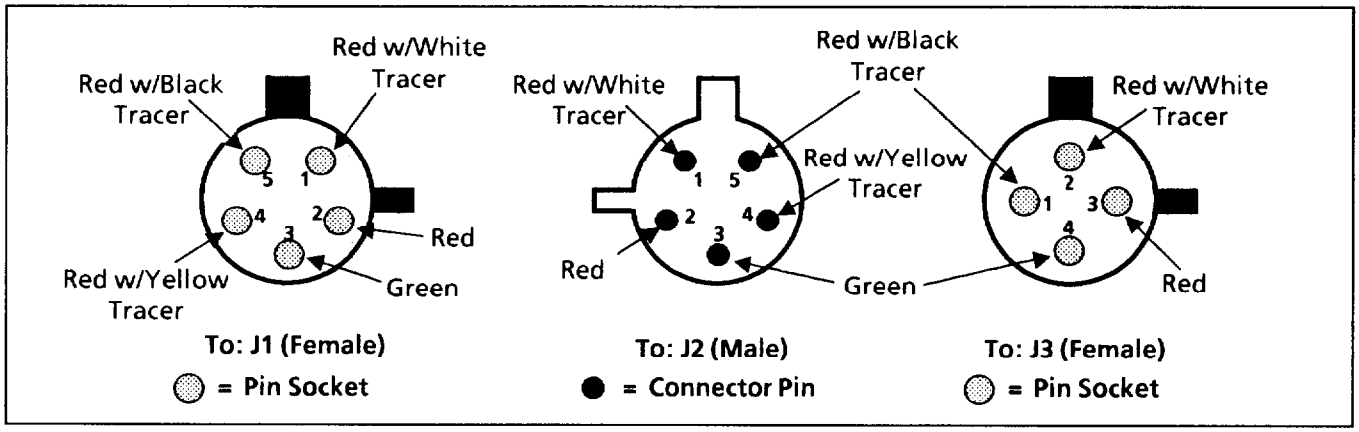
Table 3.1 identifies the signal function and wire color code for the cables that connect to J1, J2, and J3. It also shows the corresponding Brad Harrison numbers for each cable.

Table 3.1 SLS Connectors: Pin Functions and Wire Color Codes

Data	J1	J2	J3
Pin 1: Function	+ 24 VDC power input	Trigger input (+)	RS-232: Transmit data
Wire Color Code	Red with white tracer	Red with white tracer	Red with black tracer
Pin 2: Function	Analog output A	Trigger input (–)	RS-232: Receive data
Wire Color Code	Red	Red	Red with white tracer
Pin 3: Function	Common	Discrete output common	Reserved
Wire Color Code	Green	Green	Red
Pin 4: Function	Analog output B	Discrete output A	Common
Wire Color Code	Red with yellow tracer	Red with yellow tracer	Green
Pin 5: Function	Strobe trigger output	Discrete output B	N/A
Wire Color Code	Red with black tracer	Red with black tracer	N/A
Cable No.:			
6 Foot (1.8M)	70632	70621	70432
12 Foot (3.7M)	70634	70623	70434
20 Foot (6.1M)	70635	70624	70435

Figure 3.3 shows the connectors on the three cables, along with the color codes corresponding to the pins and sockets on each connector.

Figure 3.3 Cable Connectors and Wire Color Codes



Cable Connections
(continued)

Table 3.2 shows the electrical specifications for the various connector pin functions.

Table 3.2 Electrical Specifications for Pin Functions

Connector	Pin and Function	Electrical Specification
J1	Pin 1 - + 24 VDC power input	Use a + 20 to 28 VDC, NEMA/NEC class II power supply.
	Pin 2 - Analog output A	High-side sourcing, 4-20mA; max. load resistance, 500 Ohm.
	Pin 3 - Common	Common return for pins 1, 2, 4, and 5.
	Pin 4 - Analog output B	Same as Analog output A.
	Pin 5 - Strobe trigger output	+ 5VDC (active), current-limited, non-isolated. Compatible with all Allen-Bradley strobe light sources.
J2	Pin 1 - Trigger input (+)	+ 5 to 30 VDC; isolated; max. off-state leakage, 1mA; max. response time, 75μSec.
	Pin 2 - Trigger input (–)	Trigger return.
	Pin 3 - Common	Common return for discrete outputs.
	Pin 4 - Discrete output A	Max. 30 VDC or AC (peak) , NEMA/NEC class II power supply; max. current, 100mA; 300V isolation from other I/O.
	Pin 5 - Discrete output B	Same as Discrete output A.
J3	Pin 1 - RS-232 Transmit data	RS-232C, non-isolated.
	Pin 2 - RS-232 Receive data	RS-232C, non-isolated.
	Pin 3 - Common	Common return for pins 1, 2, and 4.
	Pin 4 - + 24VDC output	+ 24VDC routed from power supply input (J1, pin 1).

Power Supply: 2801-P3,P4

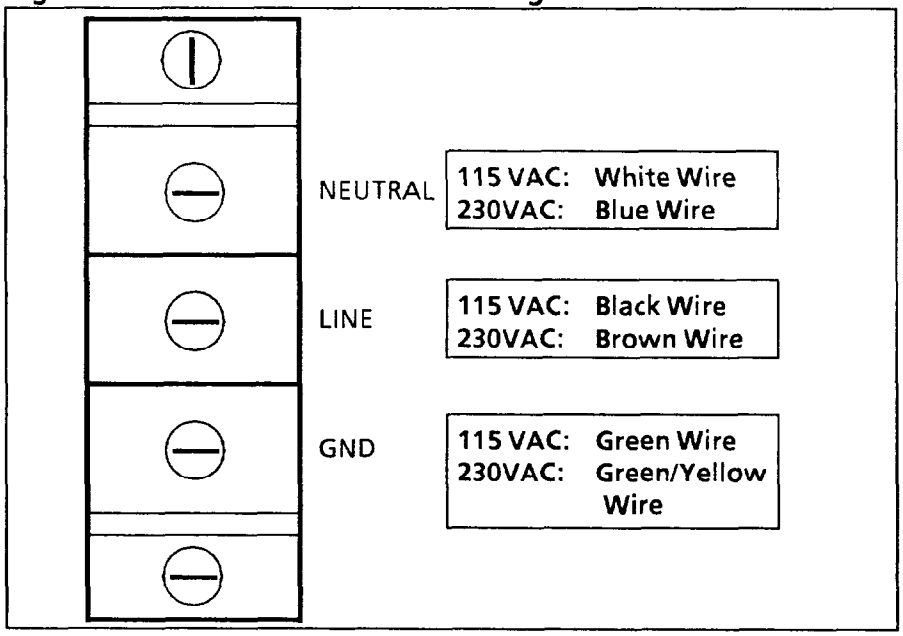
The 2801-P3 requires an input voltage of 85 to 135 VAC at 47 to 63Hz, and the 2801-P4 requires 170 to 270 VAC at 47 to 63Hz. Their output voltage is +24 VDC at 1.6A.

This section shows you how to connect AC and DC wiring to these power supplies. If you are using a power supply other than the 2801-P3 or P4, follow the power supply manufacturer's instructions for connecting these cables.

Connecting to AC Power Source

The AC power source connects to the AC terminal block on the power supply as shown in Figure 3.4.

Figure 3.4 AC Terminal Block Wiring



WARNING: Before attaching AC power wiring to the power supply:

1. Be certain that the wires are disconnected from the AC power source.
2. Be certain that the AC power source has a ground connection that conforms to local electrical codes.

Remove the cover from the AC terminal block.

For the P3 unit, when using standard 3-wire line cord or cable, connect the wires as follows:

1. Connect the green wire to the GND terminal.
2. Connect the white wire to the NEUTRAL terminal.
3. Connect the black wire to the LINE terminal.

Connecting to AC Power Source (continued)

For the P4 unit, when using a European line cord or cable, connect the line cord wires as follows:

1. Connect the green/yellow wire to the GND terminal.
2. Connect the blue wire to the NEUTRAL terminal.
3. Connect the brown wire to the LINE terminal.

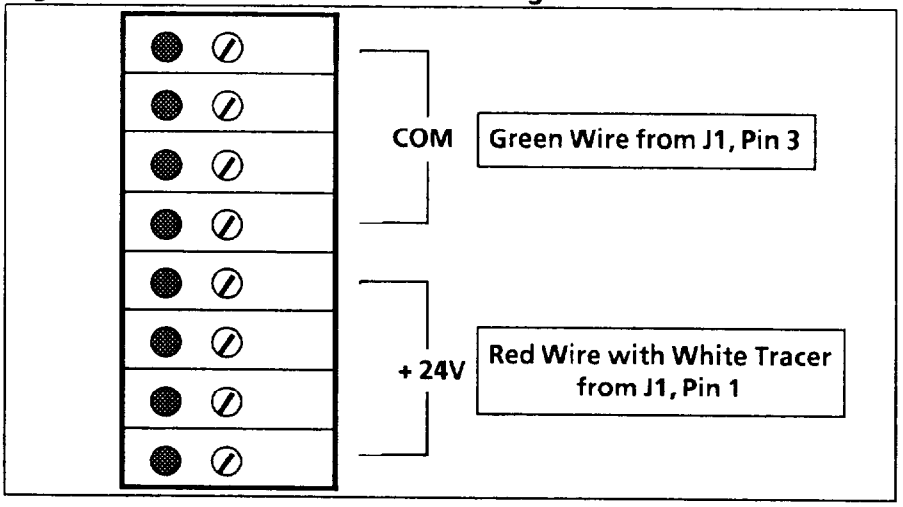
Replace the cover on the terminal block.

Do not apply AC power yet.

Connecting DC Cable

DC power enters the SLS at connector J1 through one the cables listed in Table 3.1. Two wires in the cable connect to the DC terminal block as shown in Figure 3.5.

Figure 3.5 DC Terminal Block Wiring



Note that the terminal block provides four connection points for both +24VDC and common (COM). Connect the wires as follows:

1. Remove about one-half inch of insulation from the red wire with the white tracer (from J1, pin 1).
2. Remove about one-half inch of insulation from the green wire (from J1, pin 3).
3. Insert the red wire with the white tracer into *any* connection point labeled "+24V."
4. Tighten the screw to clamp the wire securely.
5. Insert the green wire into *any* connection point labeled "COM."
6. Tighten the screw to clamp the wire securely.

Observe the orientation of the polarizing keys on the cable connector, then carefully align the cable connector with connector J1 on the SLS. Turn the collar to engage the threads on J1, then tighten the collar. Avoid using excessive force.

Powerup Check

After connecting the AC and DC cables to the power supply, check the AC power source, then perform a powerup check on the SLS to verify that it initializes properly.

CAUTION: Before applying AC power:

Be sure that the source voltage lies within the range appropriate for the power supply.

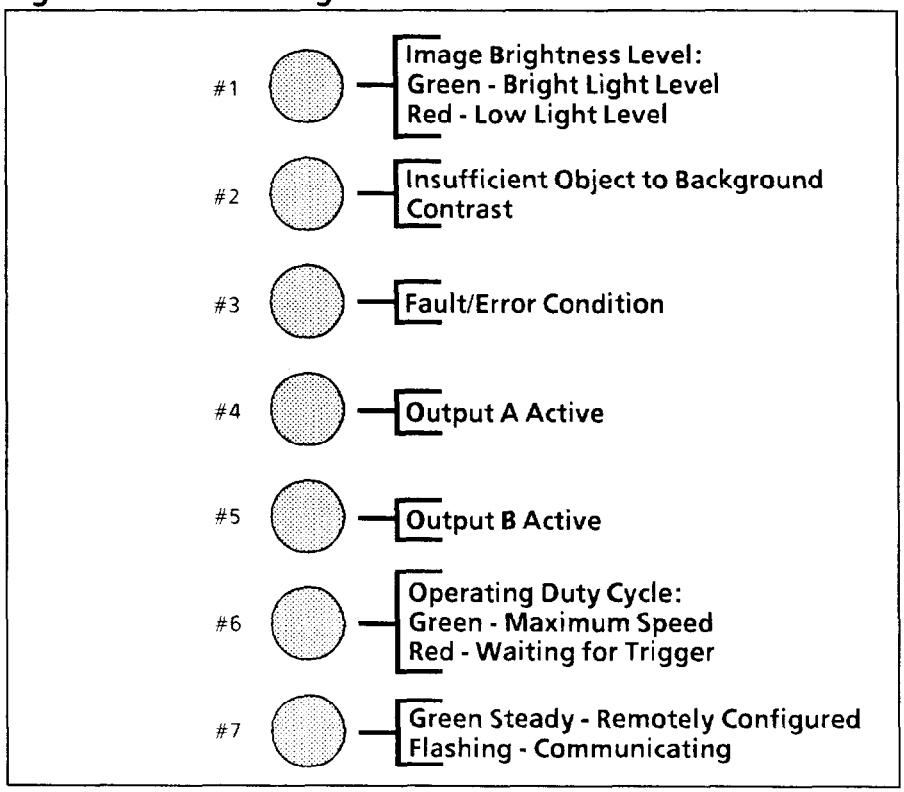
For the P3, the source voltage must be 85 to 135 VAC. For the P4, the voltage must be 170 to 270 VAC. If you are unsure about the source voltage, check it with a voltmeter.

The SLS has an internal diagnostic program that checks the status of the SLS whenever power is first applied. The program operates for about 7 seconds. During that time, the on/off pattern of the LEDs changes as the program enters each test phase.

Apply AC power to the power supply at this time. (If you are using the 2801-P3 or P4 power supply, the DC power turns *on* within ten seconds, as indicated by the POWER LED turning red.)

Initially, all seven LEDs are *on* briefly, then *off* again. Then, the top LED (#1 in Figure 3.6) turns *on*, followed by #2, #3, and so on, as each test phase is completed.

Figure 3.6 LEDs: Diagnostic Status Functions



Powerup Check (continued)

After the SLS passes all seven test phases, the LEDs turn *off* briefly, and one or more LEDs wll turn *on* again as the SLS begins normal operations.

If the diagnostic program detects an *error* condition, one or more LEDs will flash continuously. Table 3.3 shows the meanings of the flashing LEDs. In each case (except the EEPROM checksum failure), the error is "fatal," and the SLS must be replaced. If any of the error indications occur, contact your local Allen-Bradley sales office for assistance.

Table 3.3 Powerup Error Indications

Number of Flashing LEDs	Cause of Error Indication
All Seven	Software failure.
1	CPU register failure.
2	EPROM checksum failure.
3	RAM failure.
4	RAM failure.
5	Hardware revision failure.
6	EEPROM checksum failure (flashes twice, then testing continues).

After the SLS powers up successfully and begins normal operations, the LEDs that turn on depend on a number of factors, such as lighting, contrast, and function switch settings.

Notice that one of the LEDs is labeled "Fault/Error Condition." When the SLS is in operation, this LED turns *on* in any of the following eight situations:

1. Changing an SLS *switch* setting while the SLS operates using a configuration program downloaded from the SLS Configuration Support Software. (The switch change, however, has no effect on SLS operation.)

   The LED turns *on* for a few seconds, then *off*.

2. Changing a *setpoint control* setting while the SLS operates using a configuration program from the SLS Configuration Support Software. (The control change, however, has no effect on SLS operation.)

   The LED turns *on* for a few seconds, then *off*.

3. Exceeding the lighting compensation limits. Typically, this results from extremely low or high light levels.

   The LED stays *on* as long as the extreme light condition continues.

Powerup Check (continued)

4. Selecting the Run function *before* selecting and performing the corresponding Teach function. This applies only to the Parts Count and 2-D Object Size analysis functions.

   The LED stays *on* until the Teach function is performed or a different analysis function is selected.

5. Selecting the Run function along with a *different setting of the speed/resolution switch* than was used during the Teach function. This applies only to the Parts Count and 2-D Object Size analysis functions.

   The LED stays *on* until the Teach function is performed or a different analysis function is selected.

6. Selecting one of the two binary analysis functions from the DIP switches when the remote configuration switch is set to "Remote Conf. Disable." The SLS can use the binary functions *only* when the remote configuration DIP switch is set to "Remote Conf. Enable."

7. Selecting the burst acquisition mode (Configuration Support Software only), but not providing enough light on the inspected objects. The result is that the SLS clips the exposure time in order to maintain the selected burst spacing.

   For example, if the selected burst spacing were 10ms and the required exposure time were 8ms, the SLS would clip the exposure time to 5ms in order to keep the total of the exposure time plus the acquisition time from exceeding 10ms.

8. Selecting the burst acquisition mode (Configuration Support Software only) *without* specifying the burst spacing, and configuring the SLS for "Level Triggered" operation.

   When selecting burst mode *without* specifying the burst spacing, you must configure the SLS for "Edge Triggered" operation.

Observe the LED powerup sequencing as described above. After the SLS appears to have powered up successfully, continue with Chapter 4, *SLS Quick-Start Operation*. This chapter enables you to familiarize yourself with basic SLS configuration procedures and, at the same time, check the SLS for proper operation.

Chapter 4 SLS Quick-Start Operation

Chapter Objective

The objectives of this chapter are to show you the basic steps for configuring the SLS and, at the same time, enable you to check your SLS for normal operation after performing the powerup check described in Chapter 3.

Quick-Start Setup and Checkout

The quick-start operation includes the basic steps used to configure the SLS for most applications.

Note that this operation does not use the optional SLS Configuration Support Software. For information about the software, refer to the *SLS Configuration Support Software User's Manual*, Catalog No. 2804-ND002.

The quick-start operation includes these procedures:

- *Staging* – positioning the SLS, the light source, and the object(s) to be inspected. (The quick-start operation uses a special "Aiming Target," as shown in Figure 4.1, in which the black bars are the objects to be inspected. A special copy of the Aiming Target, printed on card stock, is located in the back of this manual.)

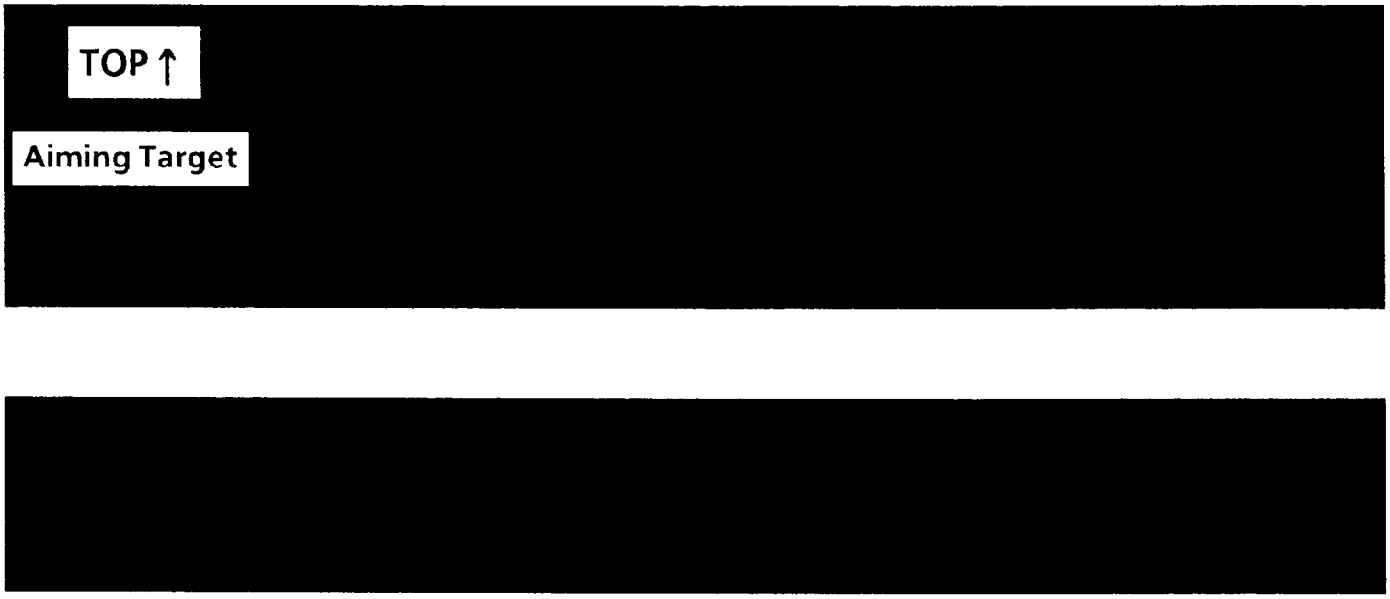
  Figure 4.2 shows the staging layout.
- *Focusing* – measuring the distance from the lens front plate to the Aiming Target and setting the lens focus to that distance.
- *Aiming* – positioning the SLS so that its linear sensor element can "see" the objects.
- *Performing Setup/Teach Operation* – operating the SLS in the setup/teach mode. During this time, the SLS acquires images in order to "learn" lighting compensation and other parameters.
- *Performing/Observing Run Operation* – operating the SLS in the run mode and observing the LEDs. During this time, the SLS acquires images of the objects, analyzes the images, and indicates the inspection results and SLS status in the LEDs.

For the purposes of the quick-start operation, prepare your SLS staging area as follows:

- Obtain a table, workbench, or other horizontal surface suitable for staging the SLS.
- Place the table next to a wall or other vertical surface suitable for mounting the Aiming Target. A source of AC power of the correct voltage must be close by.
- Obtain a small incandescent lamp that you can position close to the Aiming Target without obstructing it.
- Obtain a small tape measure. You will need it to focus the SLS.

Quick-Start Setup and Checkout
(continued)

Figure 4.1 Aiming Target



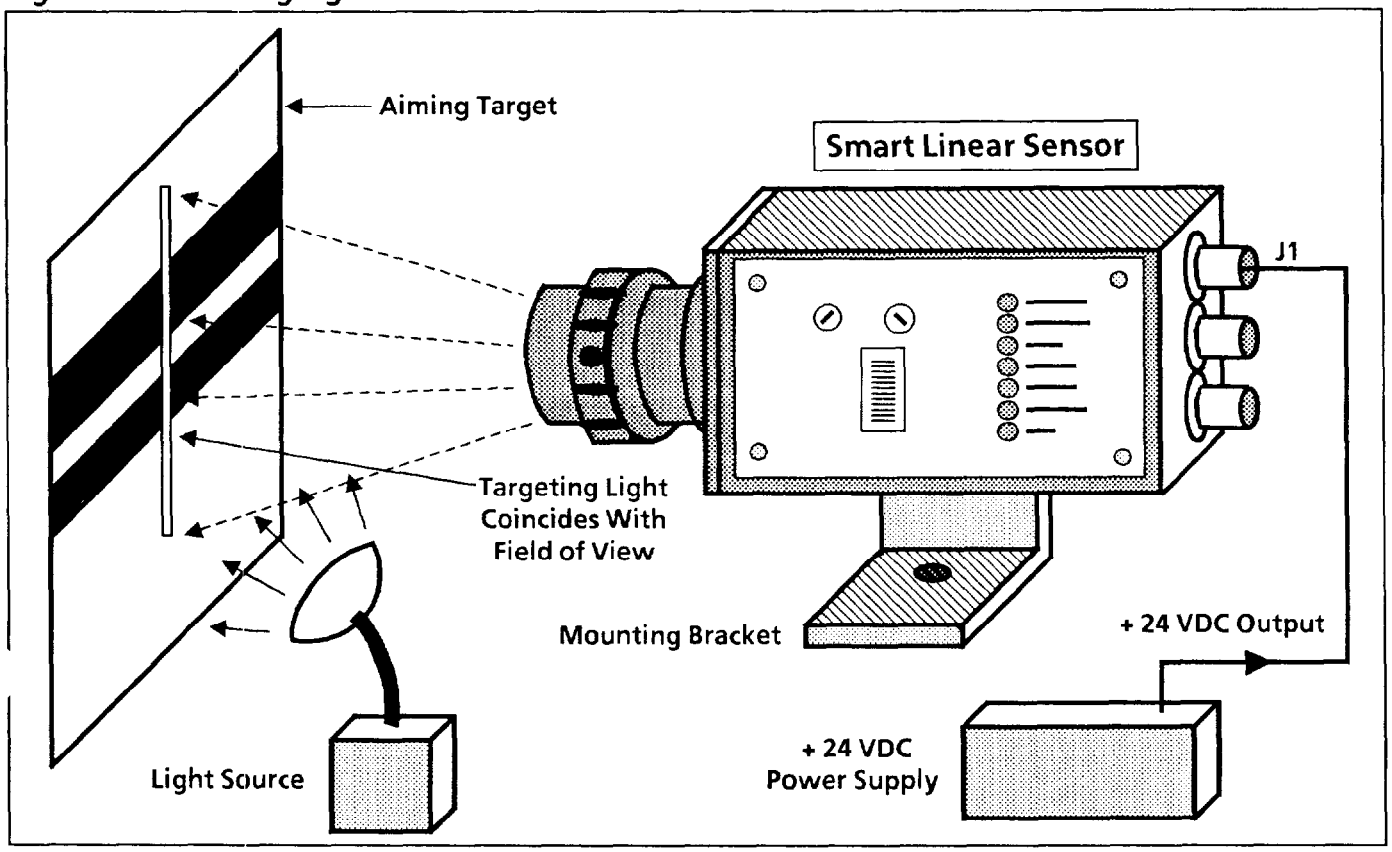
NOTE: USE THE SPECIAL AIMING TARGET PRINTED ON THE INSIDE OF THE BACK COVER.

Staging SLS

Staging involves connecting and positioning the hardware and mounting the object to be inspected (in this case, the Aiming Target).

Figure 4.2 is an example of a staging layout.

Figure 4.2 SLS Staging



Use the following steps to stage the SLS for the quick-start operation.

Your Action	Comments
Place the SLS power supply on or under the table.	
Connect the cable to connector J1 on the SLS.	Use care when aligning the connectors.
Fasten the Aiming Target to the vertical surface.	The Aiming Target is at the back of this manual. Figure 4.2 shows the Aiming Target orientation.
Attach the mounting bracket to the SLS.	Figure 4.2 shows the bracket orientation.
Position the SLS on the table with the lens facing the target.	Refer to Figure 4.2.
Connect the light source to the AC outlet, turn it on, and position it to maximize the light on the target.	

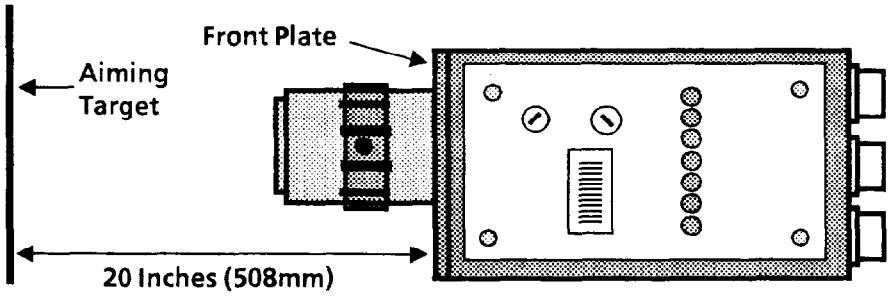
Focusing and Aiming SLS

Focusing the SLS involves measuring the distance from the lens front plate to the object to be inspected (the Aiming Target) and setting the lens to that distance.

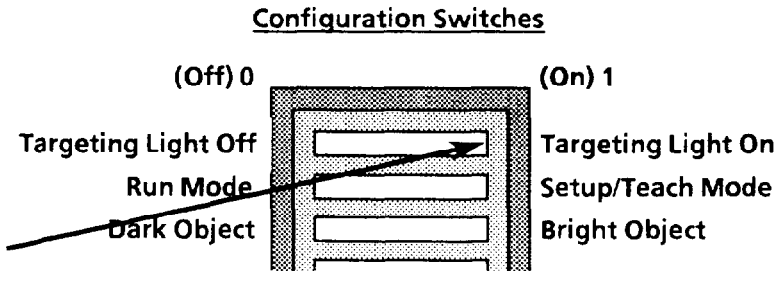
Aiming the SLS involves using the targeting light to ensure that the SLS "sees" the object to be inspected (the Aiming Target, in this case) at the correct location.

Use the following steps to focus and aim the SLS.

Your Action	Comments
Use the tape measure to position the SLS 20 inches from the Aiming Target.	Refer to the following figure.



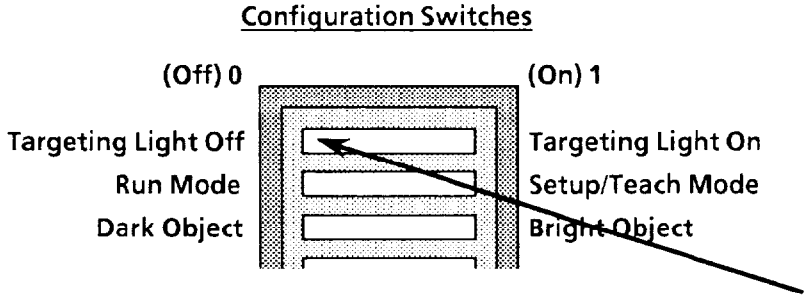
Turn the focus ring to 20 inches.	This sets the focus. No further adjustment is necessary.
Remove the panel access cover from the SLS.	The cover is secured by four captive screws.
Connect the power supply cord to the AC outlet.	Be sure the SLS completes its power up cycle as described in Chapter 3.
Turn off the light source.	
Set the targeting light switch to Targeting Light On.	Use a small screwdriver or similar device to set the switch.



NOTE: The targeting light turns *off* after two minutes or when the lens head becomes too warm. To turn it *on* again, set the switch to *off*, then *on*. If the light does not turn *on*, wait for the lens head to cool, then cycle the switch again.

Focusing and Aiming SLS (continued)

Your Action	Comments
Aim the SLS so the targeting light crosses the black bars.	Refer to Figure 4.2. The targeting light produces a thin line of light corresponding to the SLS field of view. The useful range of the light depends on the ambient light level. **NOTE:** Do *not* use the targeting light to "fine tune" the focus. Use *only* the measuring method described earlier.
If necessary, reposition the Aiming Target.	Your objective is to *center* the black bars within the targeting light.
Carefully, set the switch to Targeting Light Off.	Do not disturb the SLS position.



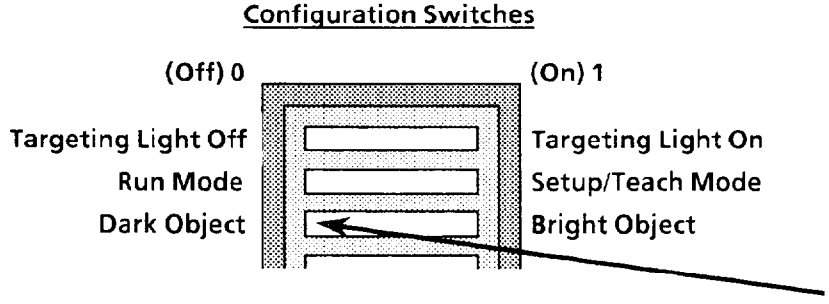
Setting Configuration Switches

In the next steps you will use the configuration switches to select the *1-D Spatial Measurement* analysis function and several configuration parameters.

The SLS will use the *1-D Spatial Measurement* function to locate the first and last edges of the black bars in the Aiming Target.

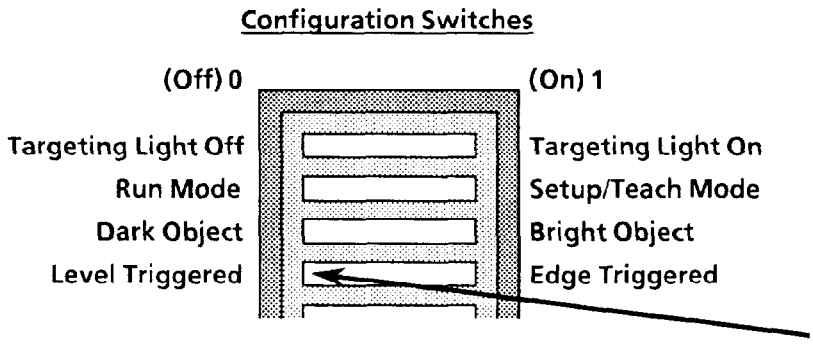
Use the following steps to set the configuration switches.

Your Action	Comments
Set the object switch to Dark Object.	This instructs the SLS to recognize the black bars on the the Aiming Target as the objects to be inspected.

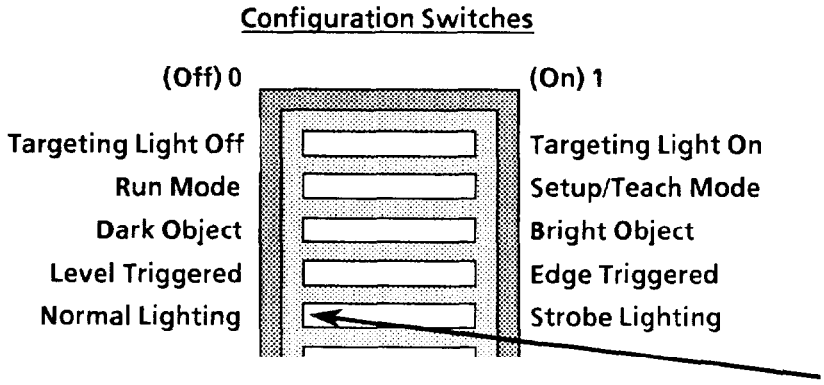


Setting Configuration Switches (continued)

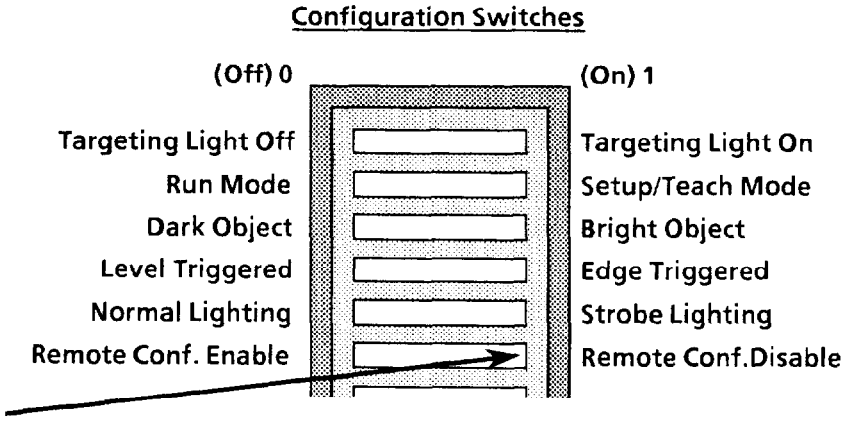
Your Action	Comments
Set the trigger mode switch to Level Triggered mode.	This enables the SLS to acquire images continuously (so long as the trigger input in connector J2 is *open* or *low*).



Set the lighting mode switch to Normal Lighting mode.	This enables the SLS to acquire images using a *continuous* lighting source such as the one you are using.

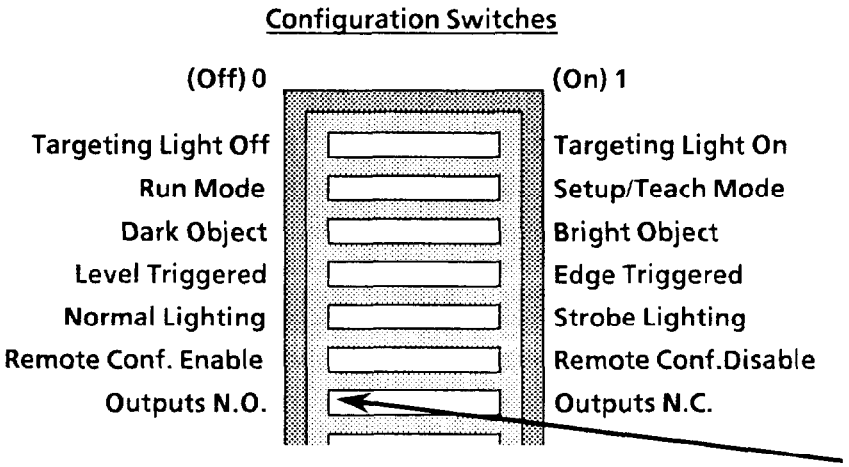


Set the remote configuration mode switch to Remote Configuration Disable.	This enables the physical switches on the SLS to control its operation. Also, it prevents the optional SLS Configuration Support Software from downloading a configuration to the SLS.

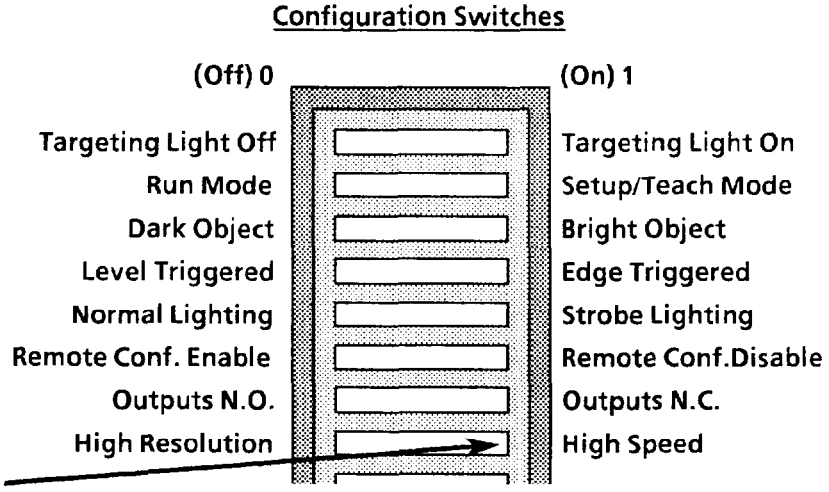


Setting Configuration Switches (continued)

Your Action	Comments
Set the output mode switch to Output N.O.	This instructs the SLS to *open* a discrete output when an inspection "result" value is *less* than the setpoint value determined by the corresponding setpoint control.

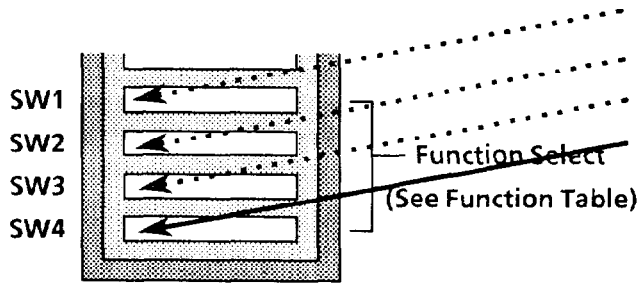


Set the resolution/speed switch to High Speed.	This instructs the SLS to operate at its highest speed, as opposed to its highest resolution. (For the quick-start operation, this setting doesn't matter.)



Setting Configuration Switches (continued)

Your Action	Comments
Set the four function select switches (SW1-4) to the "(Off) 0" position.	This setting instructs the SLS to perform the *1-D Spatial Measurement* function, which looks for the first and last edge of the object within the sensor's field of view. The SLS is now operating in the setup/teach mode. A few seconds of operation is all that is necessary for the SLS to "learn" the parameters. (In the level triggered mode, with its J2 trigger input open or high, the SLS acquires images continuously at the maximum rate.)



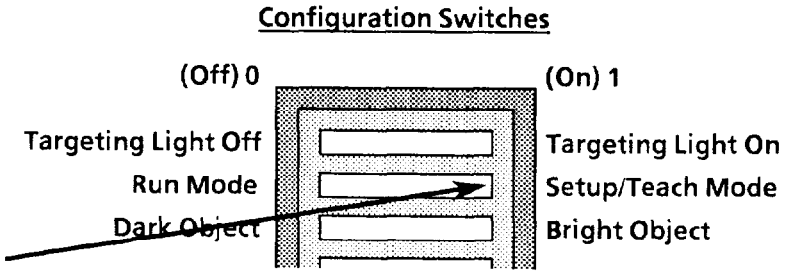
Turn the two setpoint controls to the mid-point of their ranges.	This initializes the setpoint settings for the purposes of the quick-start operation.

Performing Teach Operation

During the run mode, the SLS performs the inspection, measurement, or control task for which it is configured. Before operating in the run mode, however, the SLS must operate briefly in the setup/teach mode in order to "learn" the correct lighting compensation parameters.

Use the following steps to configure and operate the SLS in the setup/teach mode.

Your Action	Comments
Set the mode switch to Setup/Teach Mode.	This enables the SLS to "learn" the appropriate parameters.



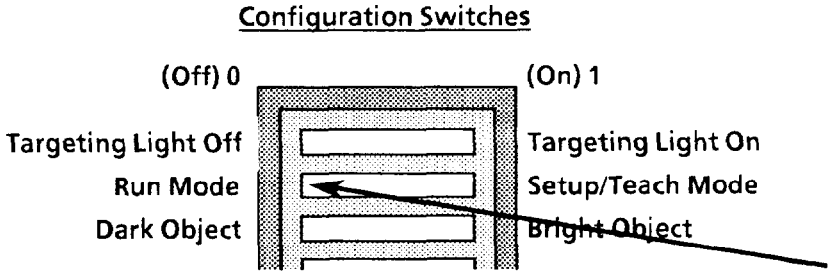
Performing Run Operation

After learning parameters in the setup/teach mode, the SLS is ready to perform its assigned inspection, measurement, or control task.

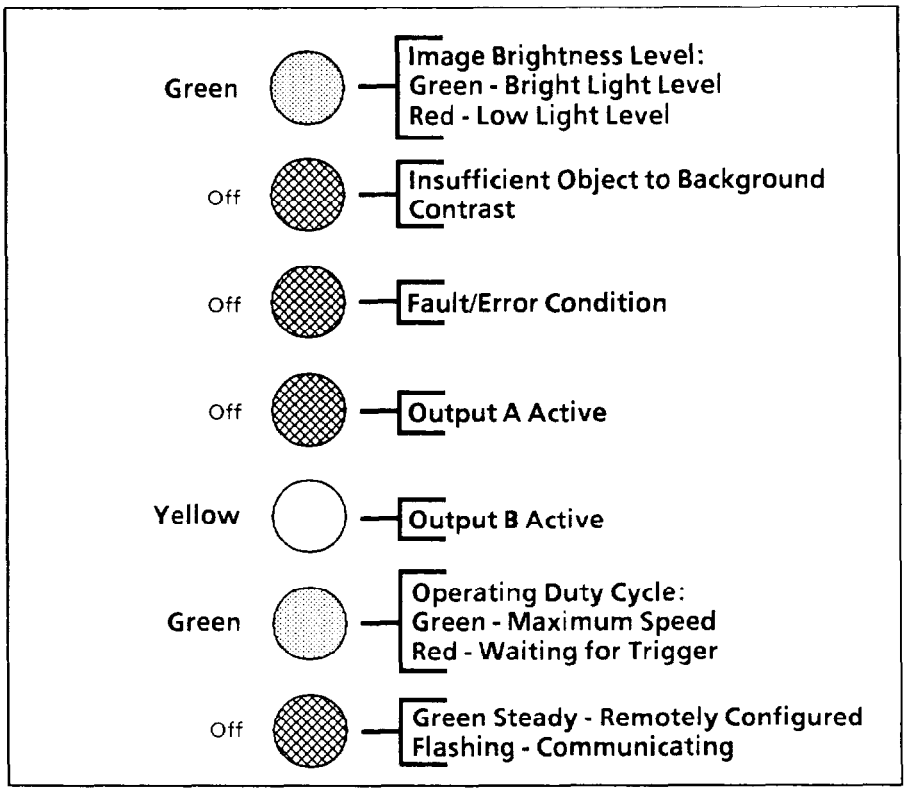
When the SLS performs the *1-D Spatial Measurement* function, it will locate the first and last edges of the black bars (the "objects") in the Aiming Target.

Use the following steps to configure and operate the SLS in the run mode.

Your Action	Comments
Set the operation mode switch to Run Mode.	This instructs the SLS to enter the run mode and perform the *1-D Spatial Measurement* function (the one you selected).

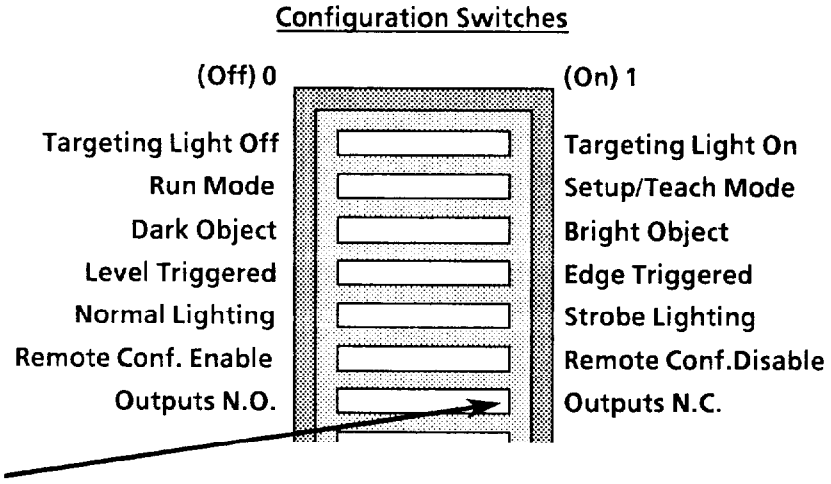


Observe the LEDs. The brightness and duty cycle LEDs should be *on*, and the output active B LED should be *on* (discrete output B is *closed*; discrete output A is *open*). The other LEDs should be *off*.

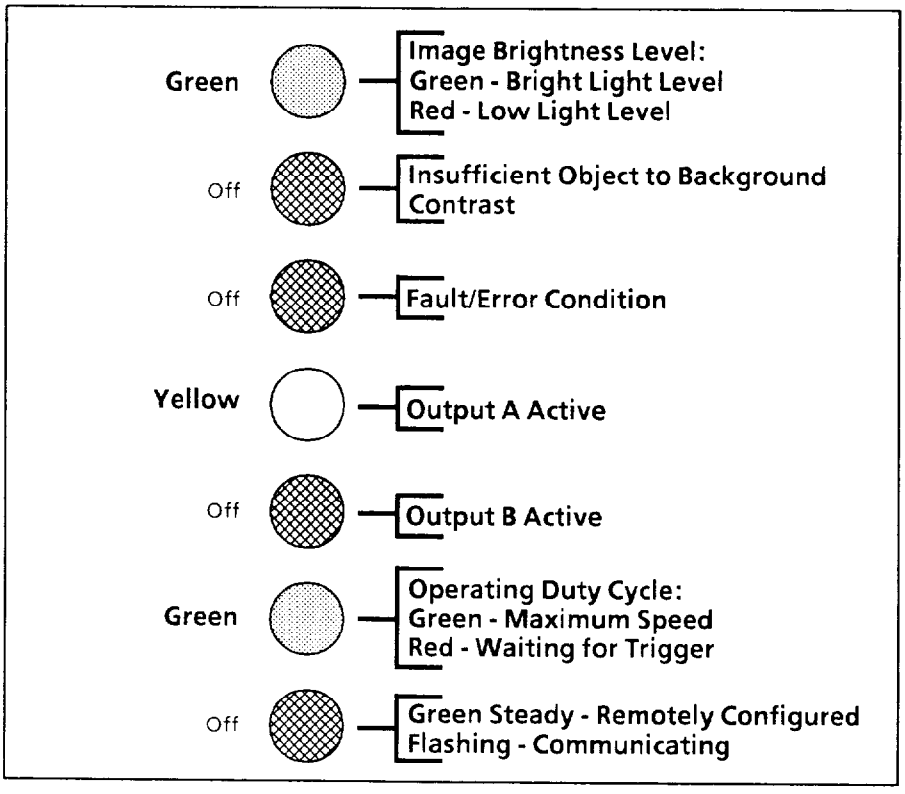


Performing Run Operation (continued)

Your Action	Comments
Set the output mode switch to Output N.C.	This instructs the SLS to *close* a discrete output when a result value is *less* than the value determined by the corresponding setpoint control.



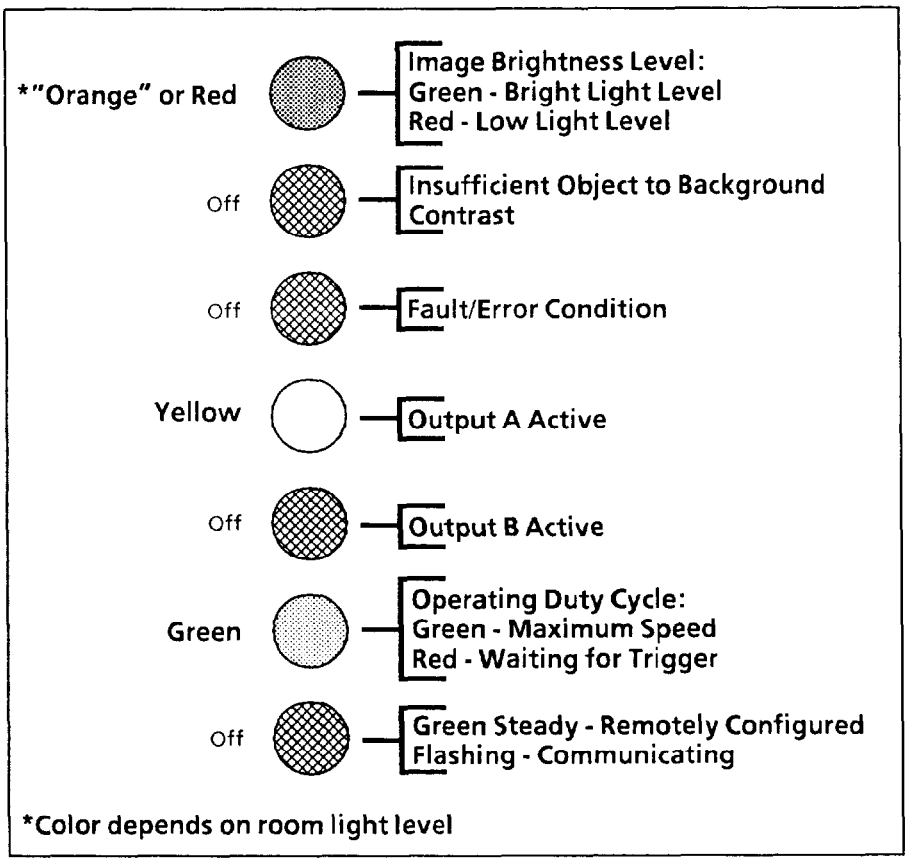
Observe the LEDs. The LEDs should now appear as follows:



The output active A LED should now be *on* and the output active B LED should be *off* (discrete output A is now *closed*; discrete output B is now *open*).

Performing Run Operation *(continued)*

Your Action	Comments
Turn off the light source.	This forces the SLS to use its lighting compensation.
Observe the LEDs.	The LEDs should now appear as follows:



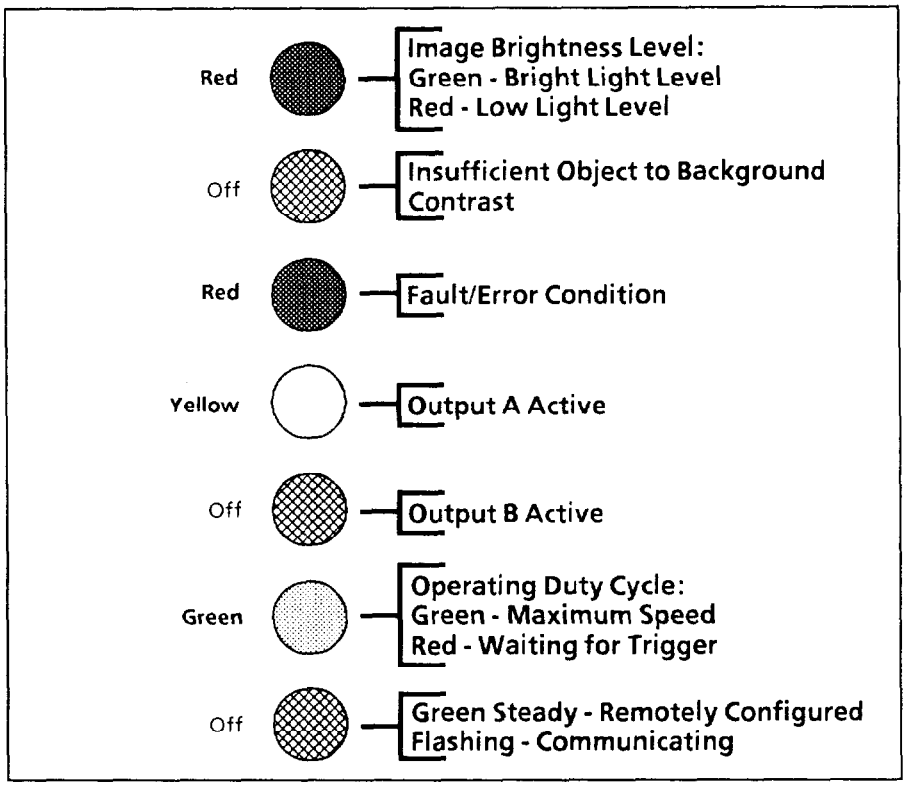
Note that the brightness LED may now be "orange" or red. This color change is likely to occur when the light level is reduced. The dimmer the room light, the more red the LED becomes. (The "orange" color effect occurs when the LED transitions from solid green to solid red.)

The other LEDs should remain the same as they were before you turned off the light.

Turn on the light source again.	The brightness LED should turn green again.
Without disturbing the SLS, block the light entering the lens.	This once again forces the SLS to use its lighting compensation function;. This time, however, the SLS will not be able to compensate for such a large change in light level.

Performing Run Operation *(continued)*

Your Action	Comments
Observe the LEDs.	The LEDs should now appear as follows:



Note that the brightness LED is now red, since the light level is quite low. Also, the fault/error LED turns *on* (red) because the lighting compensation limit has been exceeded (an *error* condition).

The other LEDs should remain the same as they were before you covered the lens.

Unblock the lens. The brightness LED should turn green again; and, after a few seconds, the fault/error LED should turn *off*.

Conclusion This completes the quick-start operation. You have just performed all the basic steps required to set up and operate your SLS. You have also verified its operational readiness.

Your SLS is now ready to be set up at its permanent operating site. Set up the SLS at that location using the same method described for the quick-start operation.

If your application requires a different analysis function than the one used in the quick-start operation, refer to Chapter 5, *SLS Analysis Functions*, for descriptions of all analysis functions and procedures for using them.

Refer also to Chapter 6, *SLS Site Installation: Requirements and Procedures* for information about installing your SLS at its permanent site and connecting it to your equipment.

Chapter 5 SLS Analysis Functions

Chapter Objective

The objective of this chapter is to show you the details of the SLS analysis functions.

Analysis Functions

An analysis function determines the operation of the SLS for a specific application. You can configure the SLS with any one of the analysis functions selectable in the lower four configuration switches (two of these functions require two switch selections, one for "*learning*" and one for *running*).

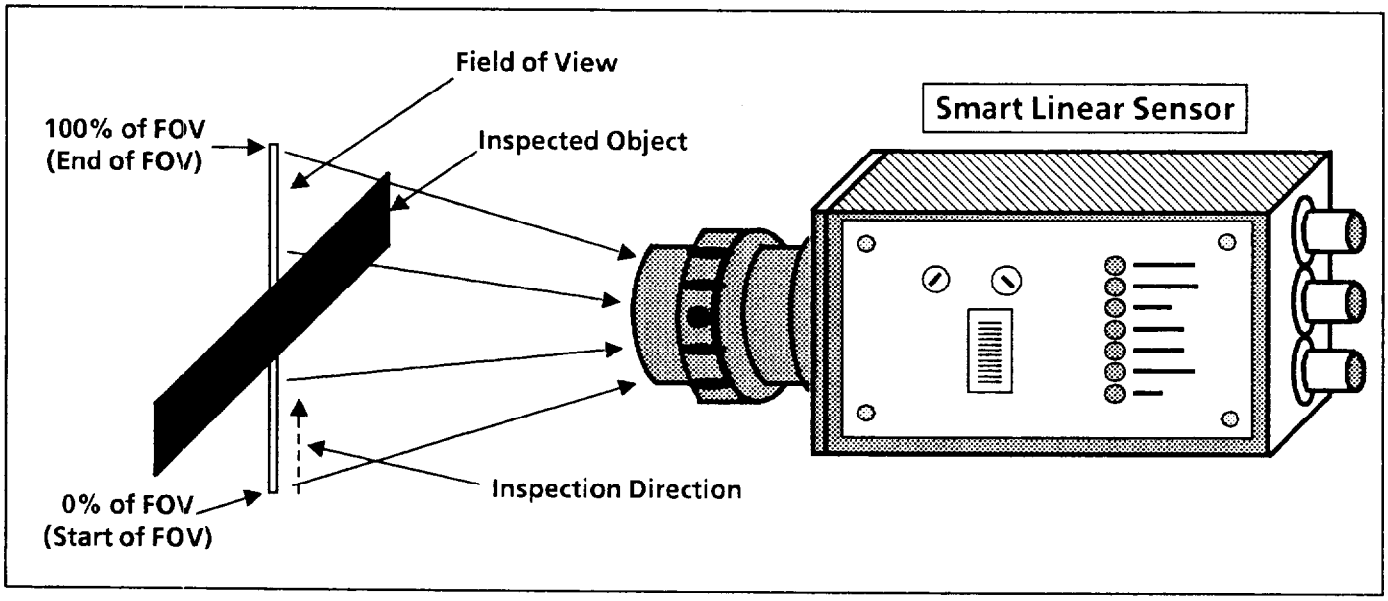
After being configured, the SLS can acquire an image of the object to be inspected or measured, analyze the image according to the selected analysis function, and issue the inspection/measurement results on its analog and discrete output lines.

Results always appear as a percentage. For example, object width results appear as a percentage of the field of view (FOV), while texture recognition results appear as a percentage of likeness to a previously "learned" object.

This chapter provides detailed descriptions of the analysis functions listed in Table 2.1 and provides simple application examples to help you understand them.

All illustrations used with these descriptions show a *vertical* FOV orientation with the inspected object(s) positioned across the FOV, as shown in Figure 5.1.

Figure 5.1 Field of View Orientation



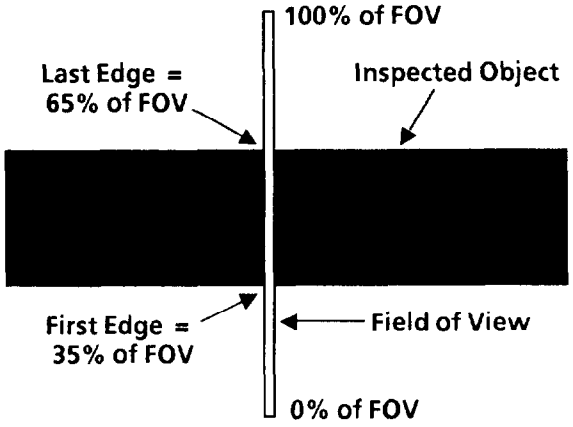
The FOV is vertical when the SLS is positioned as shown in Figure 5.1. The SLS "sees" the inspected object along the length of the FOV "line."

1-D Spatial Measurement

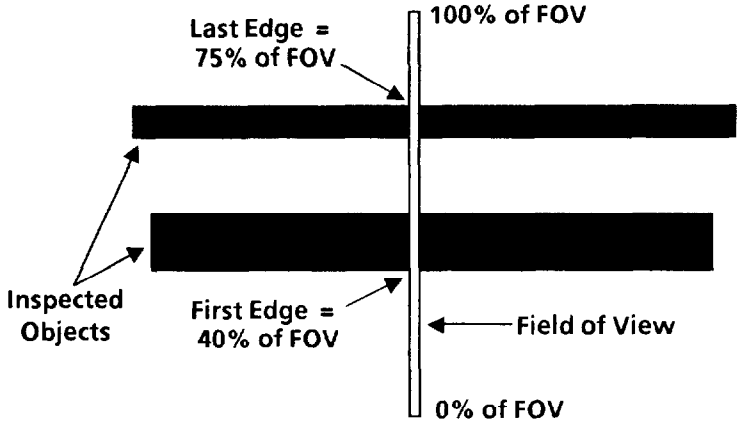
This analysis function requires at least *one* object that lies *partly* within the FOV. In this case, the SLS can locate the first or last edge of the inspected object. If the object lies *wholly* within the FOV, the SLS can locate *both* edges.

The following illustrations show you where the SLS locates the first and last edges in a variety of object positions relative to the FOV.

When one object lies wholly within the FOV, the SLS locates the first and last edges as follows:

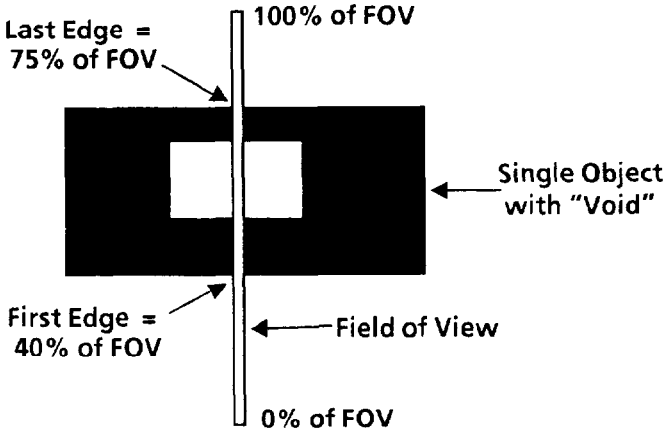


When two (or more) objects lie wholly within the FOV the SLS locates the first edge of the *first* object and the last edge of the *last* object, as follows:



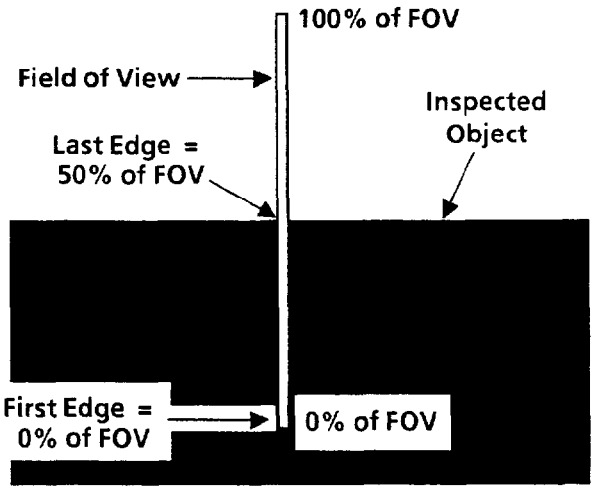
1-D Spatial Measurement *(continued)*

Since the SLS cannot determine whether the objects in the FOV are several *individual* objects, or are *one* object with *holes* ("voids") in it, the SLS locates edges in the same manner for either situation, as follows:



When part of an inspected object lies *outside* the FOV, so that the SLS cannot locate a first edge (or last edge), the SLS defaults to 0% of FOV for the location of the first edge (or 100% of FOV for the last edge).

In the following illustration, the inspected object is shown lying partially outside the 0% of FOV point.



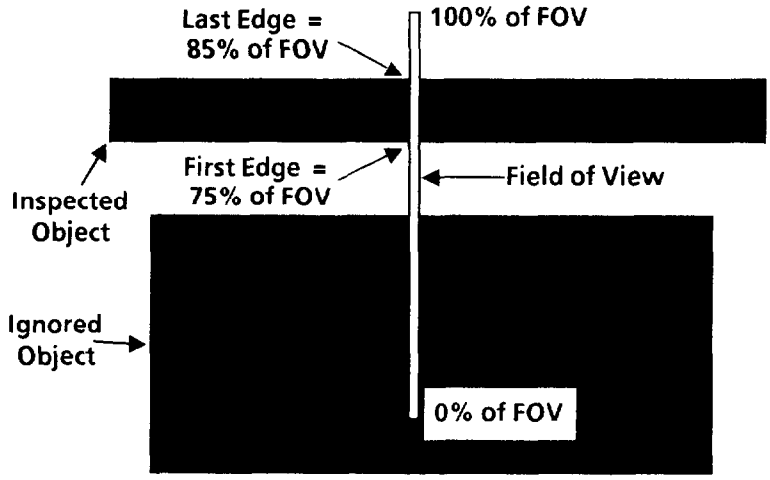
Similarly, if the object overlaps the FOV entirely, the SLS defaults to 0% of FOV and 100% of FOV for the locations of the first and last edges, respectively.

If *no* object appears in the FOV, the SLS also defaults to 0% of FOV and 100% of FOV for the locations of the first and last edges, respectively.

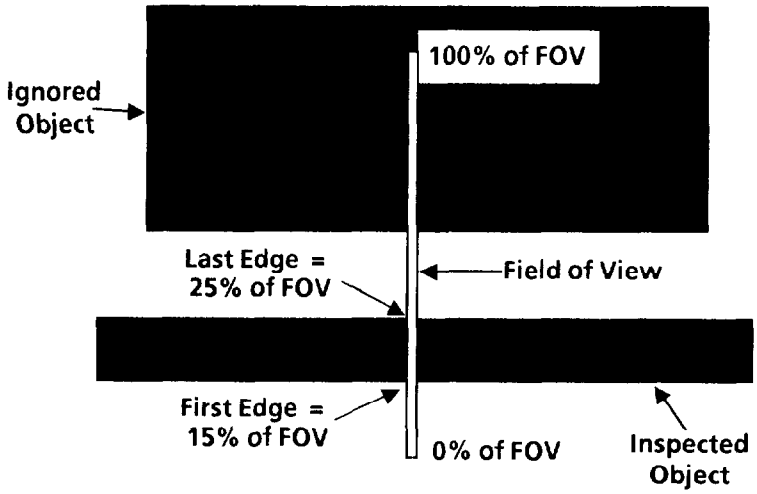
1-D Spatial Measurement (continued)

When one of two objects lies partially outside the FOV, the SLS disregards the partial object. Instead, it locates the first and last edge on the object lying wholly within the FOV.

In the following illustration, the first object lies partially outside the 0% of FOV point. In this case, the SLS ignores the first object and locates the edges of the *second* object, as follows:



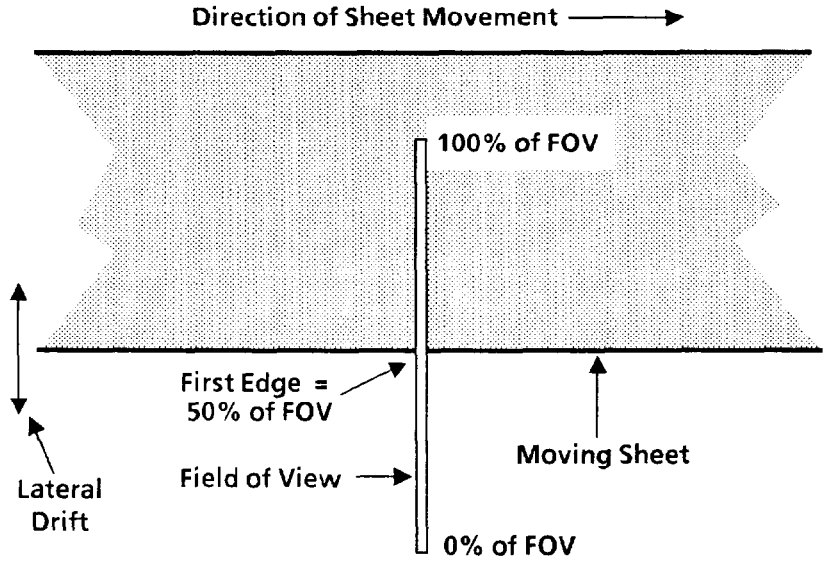
When the second object lies partially outside the 0% of FOV point, the SLS ignores that object and locates the edges of the *first* object, as follows:



Example: Here is a simple example of using the *1-D Spatial Measurement* function to track one edge of a continuous sheet product, such as paper, cloth, or sheet metal, and control the lateral position of the sheet as it moves through the processing equipment.

1-D Spatial Measurement *(continued)*

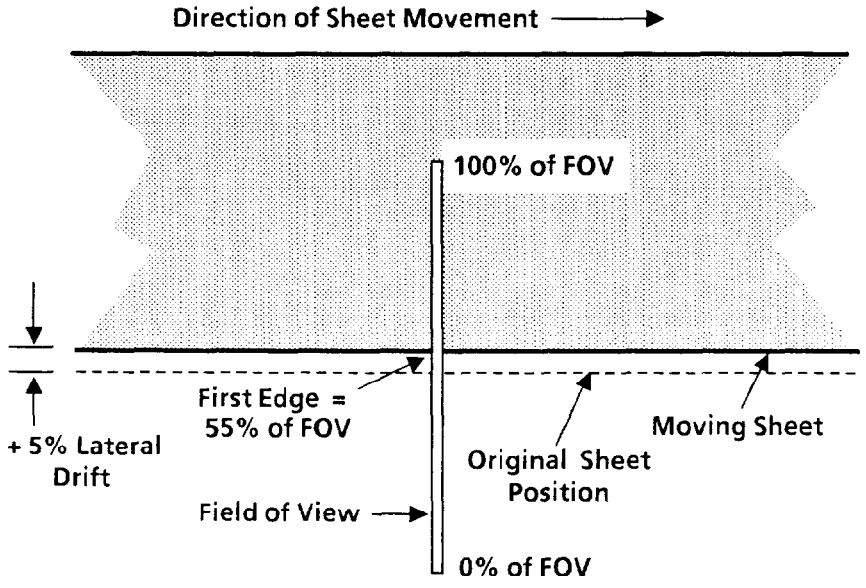
The SLS is positioned so that its FOV lies across one edge of the sheet, with the "first" edge location at the 50% of FOV point. (The "last" edge is not used in this example.)



The location "results" for the first edge appear at the Analog A output. Since the analog range is 4 to 20mA, the 50% of FOV point represents 50% of the difference between 4mA and 20mA, or 12mA. You can use this formula to determine the analog current:

Analog Current = (% of FOV × 16) + 4

If the sheet drifts laterally, the Analog A output increases or decreases proportionally. Thus, if the sheet drifts so that the first edge location moves to the 55% of FOV point, the Analog A output delivers more current: (55% × 16) + 4 = 12.80mA.



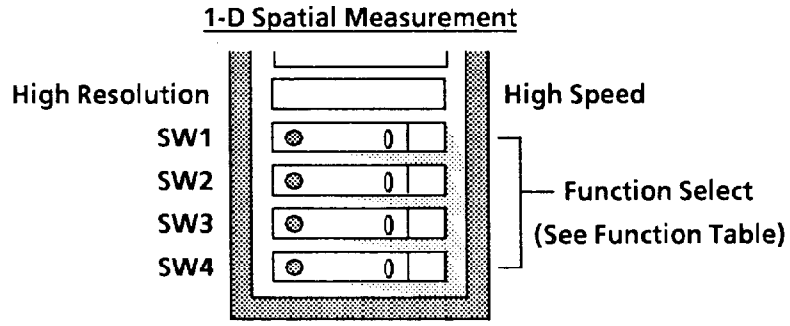
1-D Spatial Measurement (continued)

The 0.80mA increase in current could be used directly by the servo mechanism that controls the sheet position. In this case, the mechanism moves the sheet until its edge is again at the 50% of FOV point, and the current is once again 12mA.

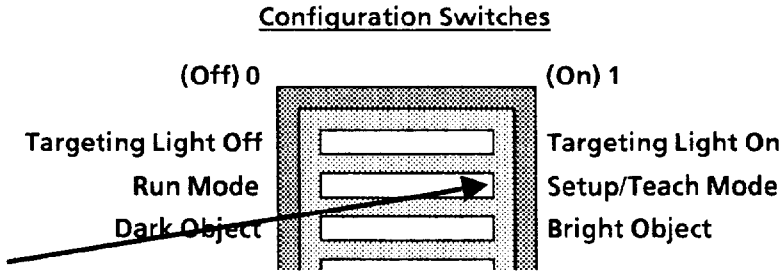
Alternatively, the current can be converted to digital values by an A-D converter connected to a programmable logic controller (PLC). In this case, the PLC could use the digitized current values in its program that controls the sheet-positioning servo mechanism.

Use the following steps to configure the SLS for the *1-D Spatial Measurement* function.

Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW4 must be *off* to enable the *1-D Spatial Measurement* function.



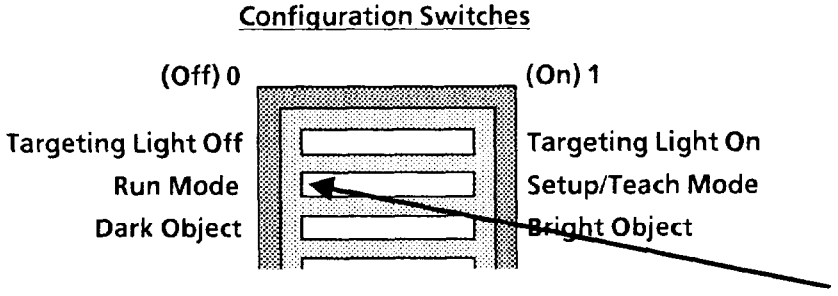
Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.
Set the operating mode switch to Setup/Teach Mode.	



The SLS "learns" the lighting compensation and other parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

1-D Spatial Measurement *(continued)*

Your Action	Comments
After a few seconds (or 10 to 20 image acquisitions), set switch to Run Mode.	The SLS saves the parameters.



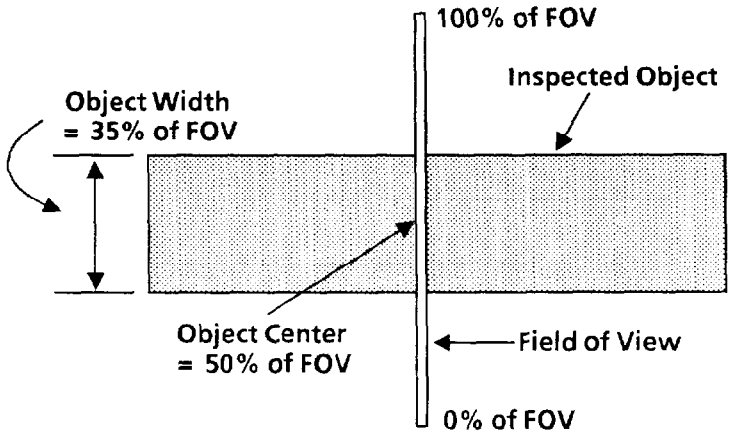
The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyze these images, and sends the results to the analog and discrete outputs.

Object Width Measurement

This analysis function requires at least *one* object that lies *wholly* within the FOV. Using this function, the SLS measures the width of the inspected object and locates the center of the object.

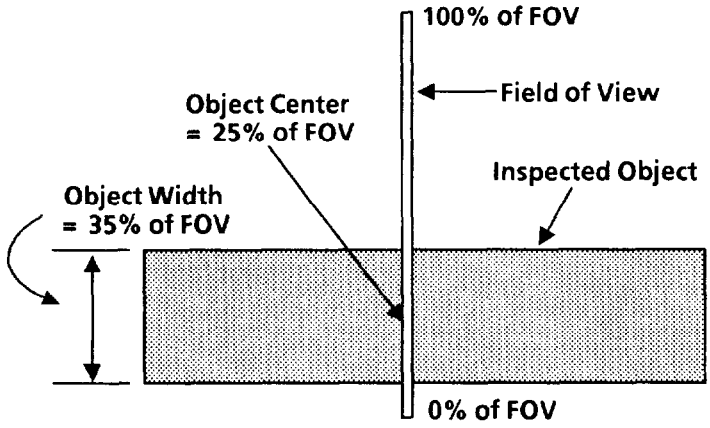
The following illustrations show you how the SLS measures object width and locates the center position with a variety of object positions relative to the FOV.

When one object lies wholly within the FOV, the SLS measures the width of that object as a percentage of FOV (regardless of its *position* along the FOV) and locates the center position *relative* to the FOV, as follows:

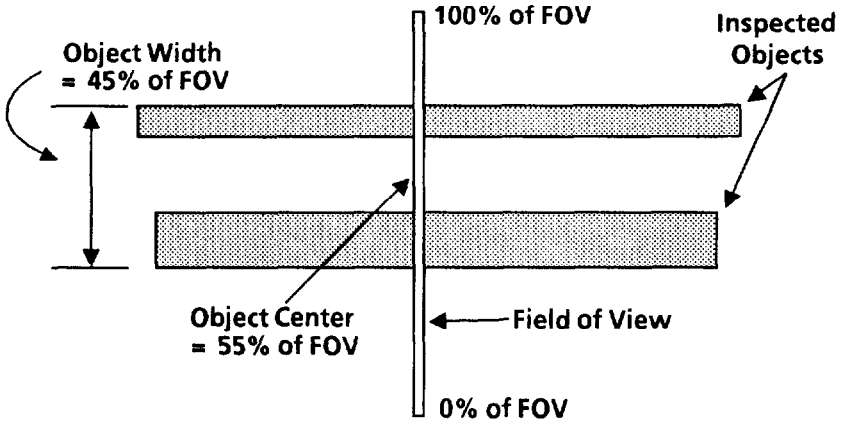


Object Width Measurement (continued)

Note that in the preceding illustration the center of the inspected object is located at the 50% of FOV point, while in the following illustration it is located at the 25% of FOV point. The *width* of the inspected object, however, remains the same in each case.



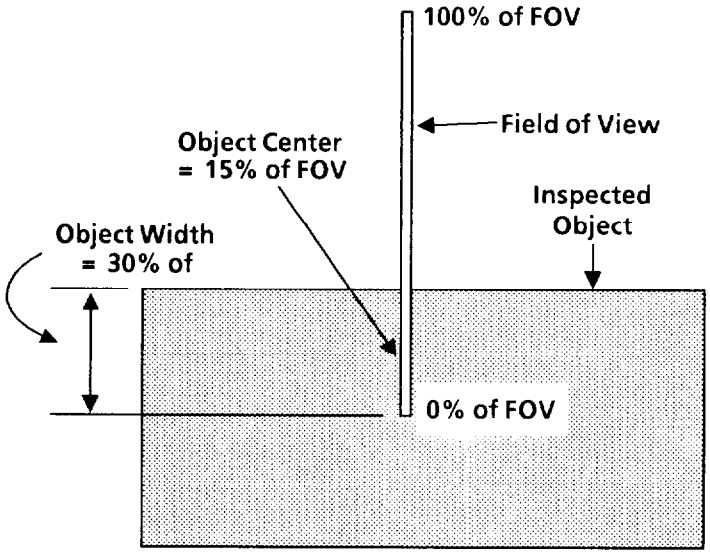
When two (or more) objects are wholly within the FOV, the SLS measures the width from the first edge of the first object to the last edge of the last object and locates the center position halfway between the two edges, relative to the FOV.



Since the SLS cannot determine whether the objects in the FOV are several *individual* objects, or are *one* object with *holes* ("voids") in it, the SLS locates edges in the same manner for either situation.

Object Width Measurement (continued)

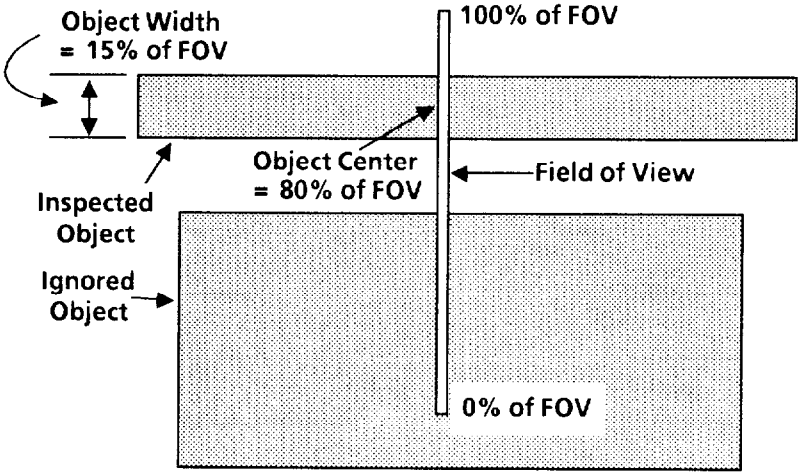
When part of an inspected object lies *outside* the FOV, so that the SLS cannot measure the full width of the object, the width defaults to the part of the object that the SLS can "see," starting with the 0% of FOV point (or ending with the 100% of FOV point).



If the inspected object overlaps the FOV entirely, or if *no* object appears in the FOV, the width and center position both default to 0% of FOV.

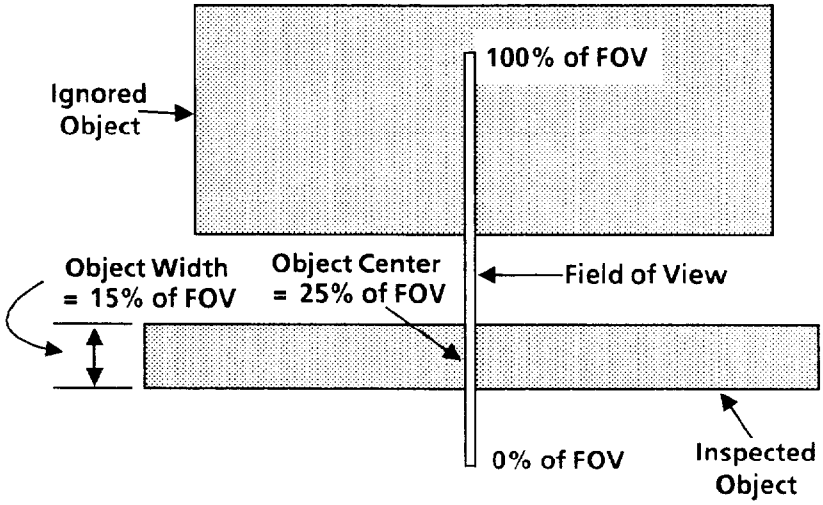
When one of two objects lies partially outside the FOV, the SLS disregards the partial object. Instead, it measures the width of the object lying wholly within the FOV and locates the object's center position.

In the following illustration, the first object lies beyond the 0% of FOV point. In this case, the SLS locates the edges of the *second* object, as follows:



Object Width Measurement (continued)

If the *second* object lies beyond the 100% of FOV point, the SLS locates the edges of the *first* object, as follows:



Example: Here is a simple example of using the *Object Width Measurement* function to measure the width of a disc brake rotor and check it for runout.

The SLS is positioned so that its FOV lies parallel to the rotor axis and perpendicular to the friction surfaces of the rotor.

The illustration on the following page shows the FOV relative to the brake rotor.

Note that **A** shows the complete brake rotor assembly, while **B** shows the FOV located across the rotor near the edge.

The object width "results" appear at the Analog A output on the SLS. Since the Analog A output represents the 80% of FOV point in this example, using the formula

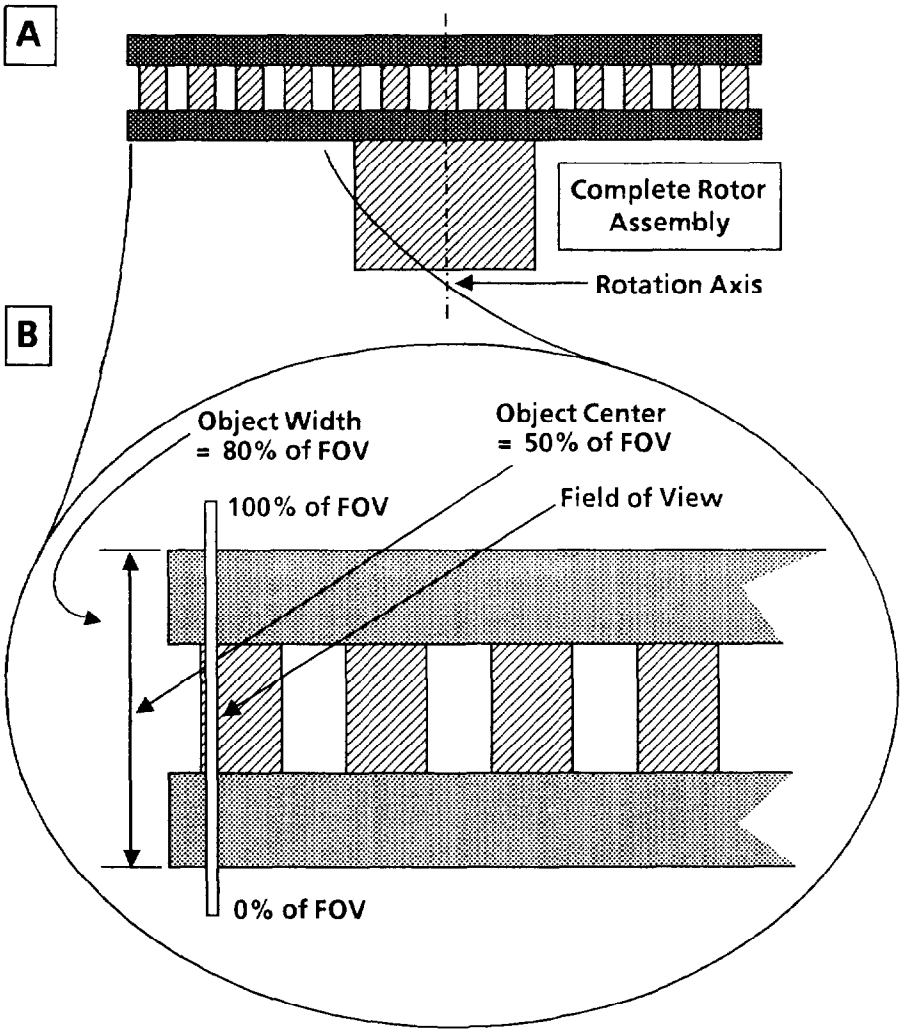
Analog Current = (% of FOV x 16) + 4

the current is 16.8mA. If the rotor thickness varies as the rotor rotates, the object width results will vary up or down from the 80% of FOV point, and the Analog A output current will increase or decrease proportionally.

The object center "results" appear at the Analog B output on the SLS. Since the Analog B output represents the 50% of FOV point in this example, using the formula above, the current is 12mA.

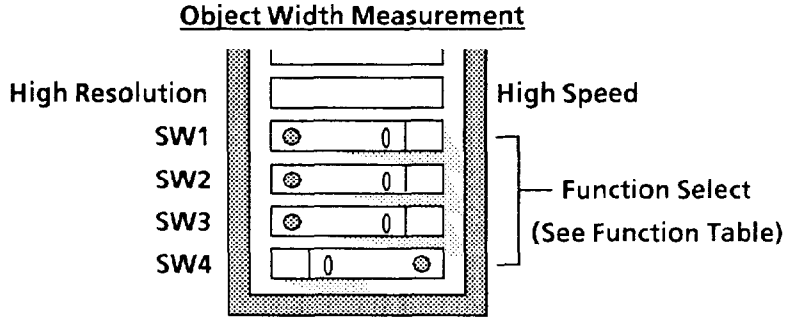
If the object center position varies as the rotor rotates, the center position results will vary up or down from its 50% of FOV point, and the Analog B output current will increase or decrease proportionally. This indicates the degree of rotor runout.

Object Width Measurement (continued)



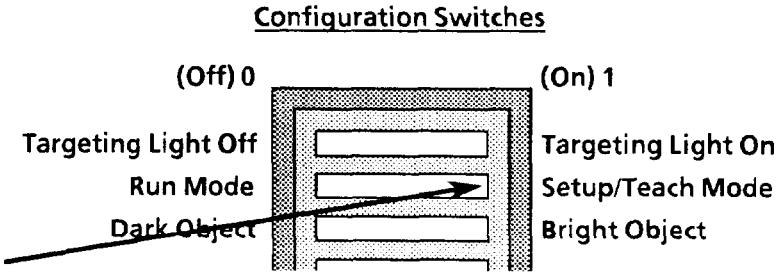
Use the following steps to configure the SLS for the *Object Width Measurement* function.

Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW3 must be *off* and SW4 must be *on* to enable the *Object Width Measurement* function.



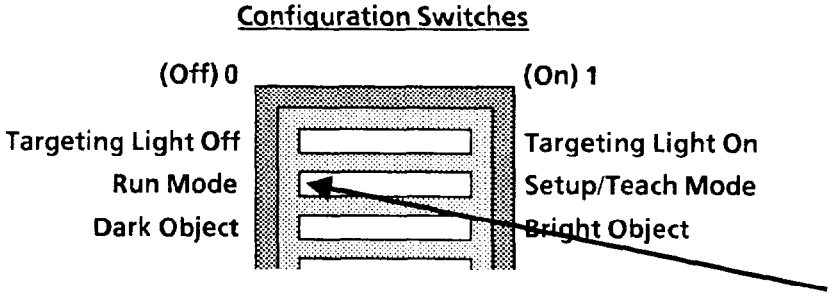
Object Width Measurement (continued)

Your Action	Comments
Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.
Set the operating mode switch to Setup/Teach Mode.	



The SLS "learns" the lighting compensation and other parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

After a few seconds (or 10 to 20 image acquisitions), set switch to Run Mode.	The SLS saves the parameters.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

Object Void Measurement

This analysis function requires *two* or more objects *wholly* within the FOV, or *one* object with one or more holes. The SLS regards the spaces between objects (or the holes in a single object) as "voids."

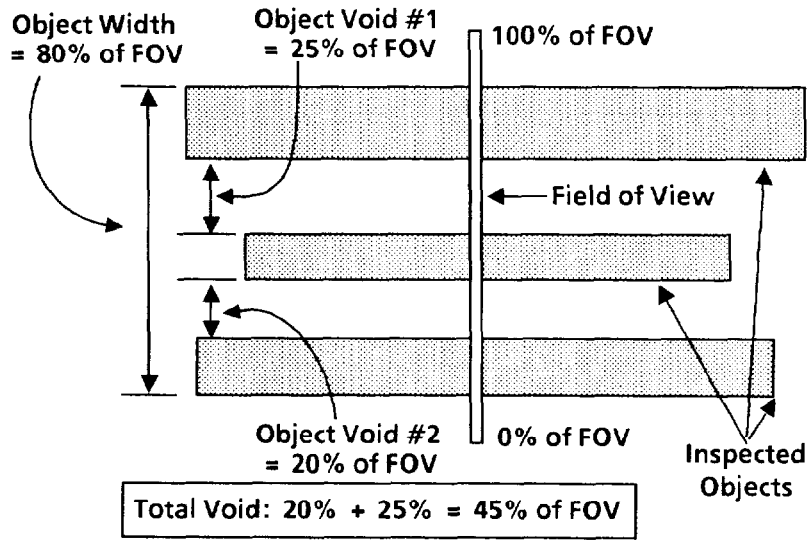
When the inspected objects are *dark* (relative to their background), a "void" is any occurrence of the *light* background between the first and last edges. The opposite is true for *bright* objects.

Using this function, the SLS measures the *total* void between the first edge of the first object and the last edge of the last object as a percentage of the FOV. The SLS also measures the width between these edges as a percentage of the FOV.

When only one solid object lies wholly within the FOV, the SLS measures the width of that object, but does *not* measure the void between that object and another object lying partially outside the FOV. The void size in this case is 0.

The following illustrations show you how the SLS measures voids and object width.

When two (or more) objects lie wholly within the FOV, the SLS measures the width between the first and last edges and the total void between these edges, as follows.

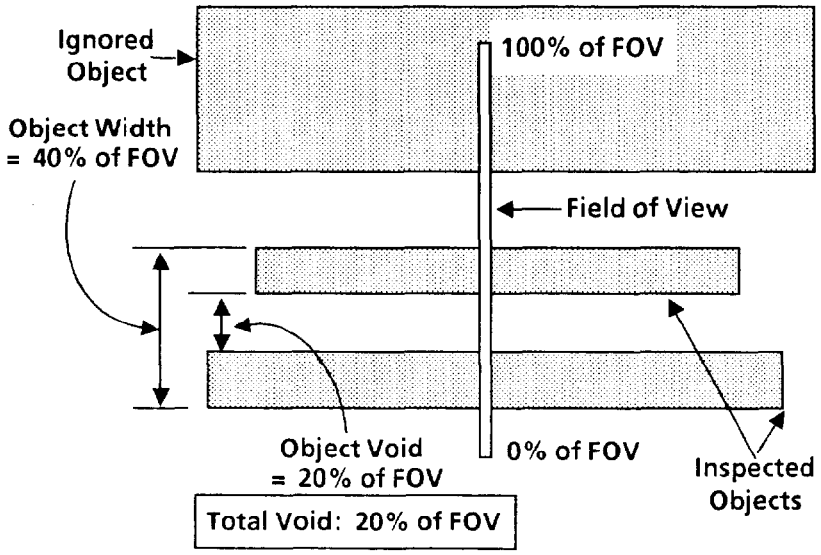


Since the SLS cannot determine whether the objects in the FOV are several *individual* objects, or are *one* object with *holes* ("voids") in it, the SLS locates edges and voids in the same manner for either situation.

When two objects lie wholly within the FOV, and a *third* object lies partially *outside* the FOV, the SLS measures the width between the first edge of the first object and the last edge of the second object and the void between these two objects, but *ignores* the third object.

Object Void Measurement (continued)

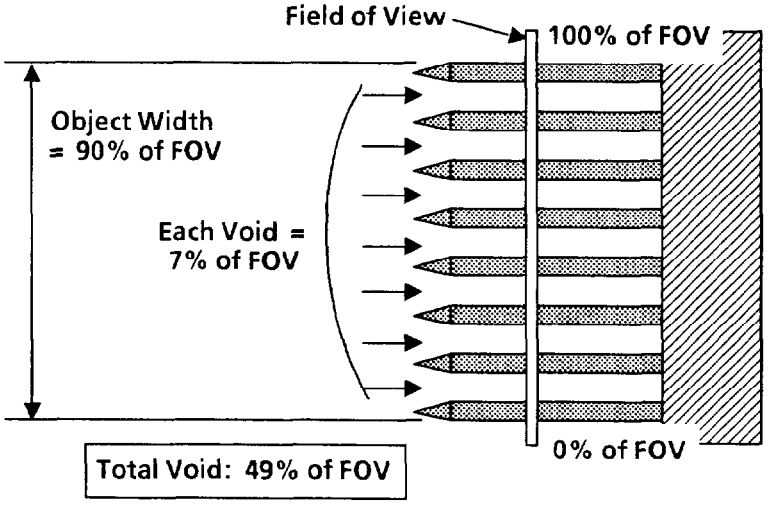
In the following illustration, two objects lie within the FOV, but one object lies partially outside the 100% of FOV point.



If a single object overlaps the FOV entirely, or if *no* object appears in the FOV, the width and total void both default to 0% of FOV.

Example: Here is a simple example of using the *Object Void Measurement* function to detect a missing pin in a connector.

The SLS is positioned so that its FOV lies across the pins, as shown in the following illustration.



In this example, each void between the pins occupies 7% of FOV, and each pin occupies 5% of FOV. When all pins are present, the total void is $7 \times 7\% = 49\%$ of FOV.

Object Void Measurement *(continued)*

The total void "results" appear at the Analog A output on the SLS. Since the analog range is 4 to 20mA, the 49% of FOV value represents 49% of the difference between 4mA and 20mA. Using this formula:

Analog Current = (% of FOV × 16) + 4

the Analog A current is (49% × 16) + 4 = 11.84mA. This is the current when all pins are *present*. If a pin is missing, however, the current will change.

If an *end* pin is missing, the total void decreases by 7%, since there are now only six voids. Thus, the total void decreases to 6 × 7% = 42%, and the Analog A output delivers less current: (42% × 16) + 4 = 10.72mA.

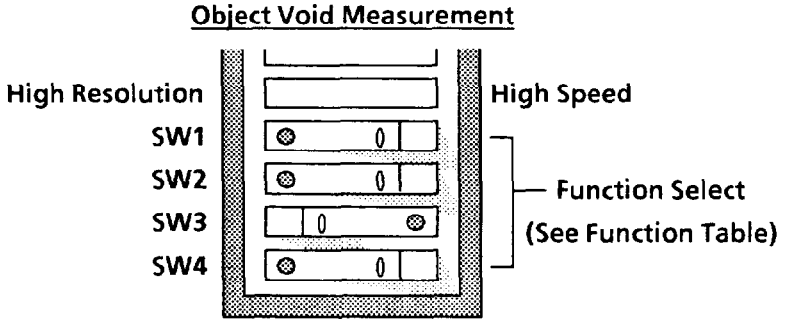
If a *middle* pin is missing, the total void increases by 5%, the width of the missing pin. Thus, the total void increases to 54%, and the Analog A output delivers more current: (54% × 16) + 4 = 12.64mA.

The object width "results" appear at the Analog B output on the SLS. Since the object width in this example equals 90% of the FOV (with both end pins present), the normal Analog B current is this: (90% × 16) + 4 = 18.4mA. If an end pin is missing, however, the current changes.

For example, if one end pin is missing, the width decreases by 12% (the combined width of one pin and one void) to 78%, and the Analog B output delivers less current: (78% × 16) + 4 = 16.48mA.

Use the following steps to configure the SLS for the *Object Void Measurement* function.

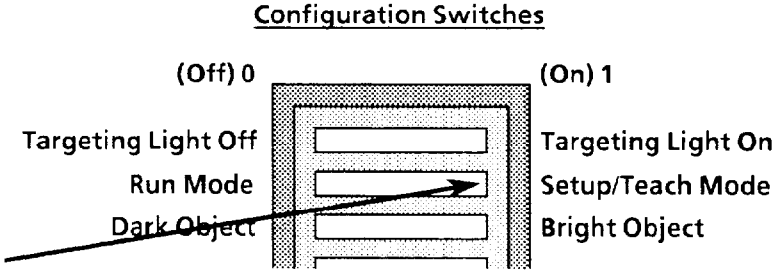
Your Action	Comments
Set the lower four function switches as shown.	SW1, SW2, and SW4 must be *off* and SW3 must be *on* to enable the *Object Void Measurement* function.



Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

Object Void Measurement *(continued)*

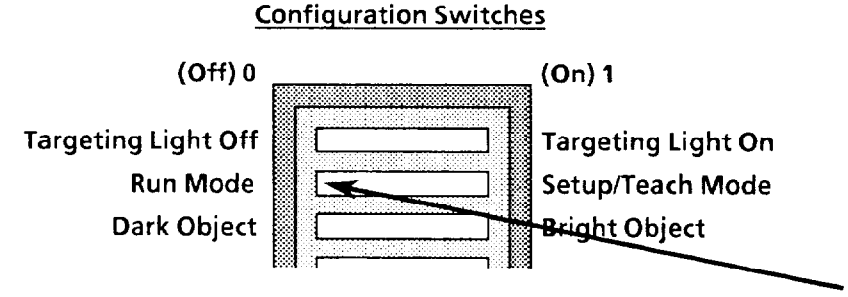
Set the operating mode switch to Setup/Teach Mode.



The SLS "learns" the lighting compensation and other parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

After a few seconds (or 10 to 20 image acquisitions), set switch to Run Mode.

The SLS saves the parameters.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

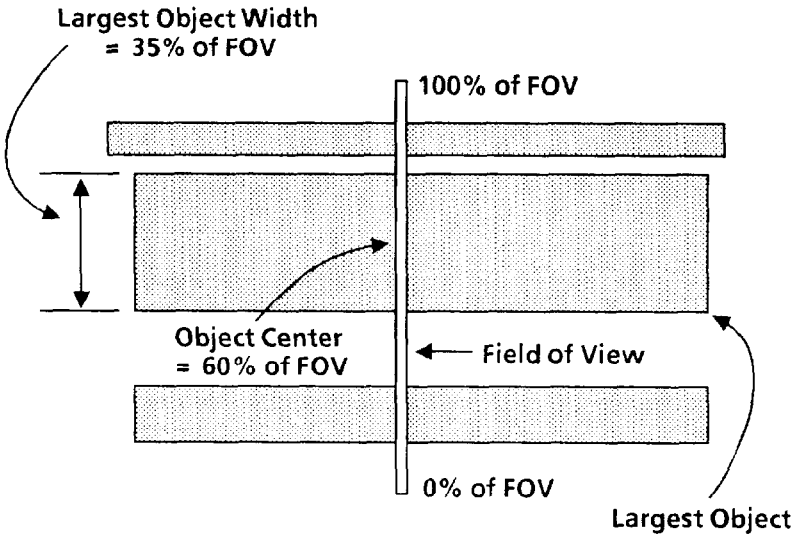
Largest Object Width

This analysis function (available only in the Series B SLS) is similar to the *Object Width Measurement* function, except that the SLS measures the width of the *largest* inspected object and locates the center of that object.

When two (or more) objects are wholly within the FOV, the SLS measures the width between the two edges of the *largest* object and locates the center position of that object halfway between the two edges, relative to the FOV.

Largest Object Width (continued)

The SLS measures the width of the largest object as a percentage of FOV (regardless of its *position* along the FOV) and locates the center position *relative* to the FOV, as shown in the following illustration.



Since the SLS cannot determine whether the objects in the FOV are several *individual* objects, or are *one* object with *holes* ("voids") in it, the SLS assumes that the objects are separate. It regards each pair of edges to be another object.

Example: Here is a simple example of using the *Largest Object Width* function to measure the width of objects that are normally accompanied (in the FOV) by several smaller objects. Since these objects are, in effect, visual "noise," the *Largest Object Width* function can act as a "filter" to eliminate the "noise."

The SLS is positioned so that the FOV is perpendicular to the path of the inspected objects, as shown in the illustration on the following page.

The SLS analyzes each pair of edges along the FOV and identifies the *largest* object as the pair of edges that has the greatest distance between them. The SLS *ignores* the smaller objects.

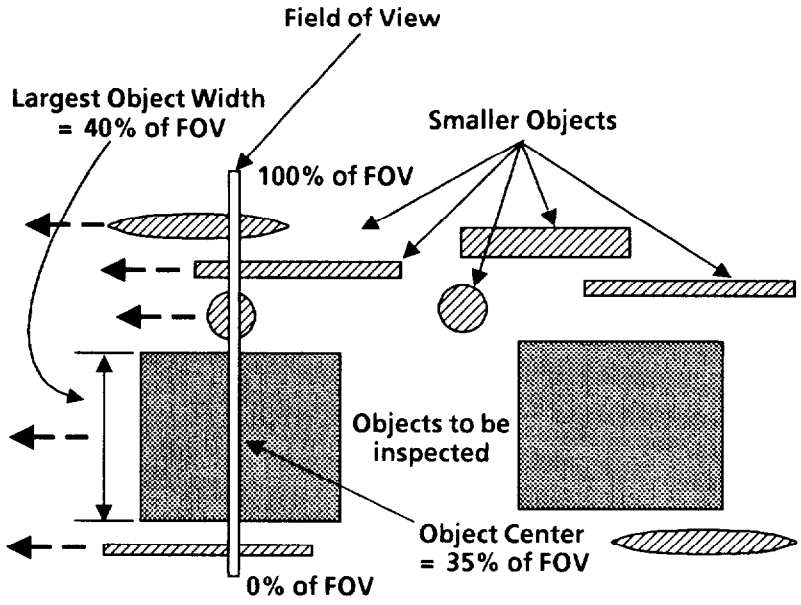
The largest object width "results" appear at the Analog A output on the SLS. Since the Analog A output represents 40% of the FOV in this example, using the formula

$$\text{Analog Current} = (\%\ \text{of FOV} \times 16) + 4$$

the current is 10.4mA.

The object center "results" appear at the Analog B output on the SLS. Since the Analog B output represents 35% of the FOV in this example, using the formula above, the current is 9.6mA.

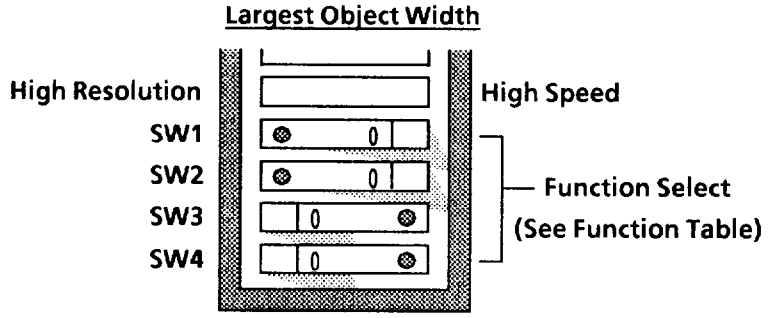
Largest Object Width (continued)



NOTE: For optimum results, the contrast between the largest object and the background luminance should equal or exceed the contrast of all other objects expected to appear in the FOV with the largest object.

Use the following steps to configure the SLS for the *Largest Object Width* function.

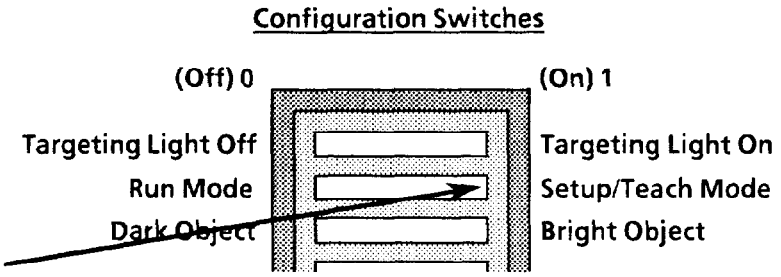
Your Action	Comments
Set the lower four function switches as shown.	SW1 and SW2 must be *off* and SW3 and SW4 must be *on* to enable the *Largest Object Width* function.



Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

Largest Object Width *(continued)*

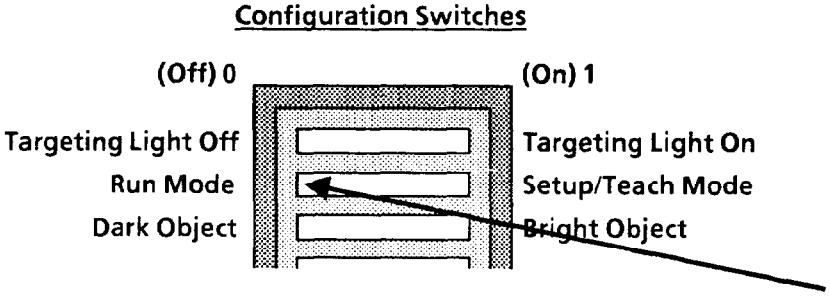
Your Action	Comments
Set the operating mode switch to Setup/Teach Mode.	



The SLS "learns" the lighting compensation and other parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

After a few seconds (or 10 to 20 image acquisitions), set switch to Run Mode.

The SLS saves the parameters.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

1-D Object Recognition

This analysis function requires at least *one* object lying *wholly* within the FOV. When *two* or more objects appear in the FOV, the SLS interprets them as *one* object, from the first edge of the first object to the last edge of the last object.

Using the *1-D Object Recognition* function, the SLS compares the gray scale pattern of an *ideal* object with the gray scale pattern of the object currently in the FOV. These gray scale patterns are the recognition "signatures" of the two objects, and they indicate the variations in *brightness* (that is, *shades of gray*) of the object along the length of the FOV.

1-D Object Recognition (continued)

During the setup/teach mode, the SLS "learns" the gray scale pattern of an ideal object. This is the "recognition signature." At the start of the run mode, the SLS stores the recognition signature in its memory.

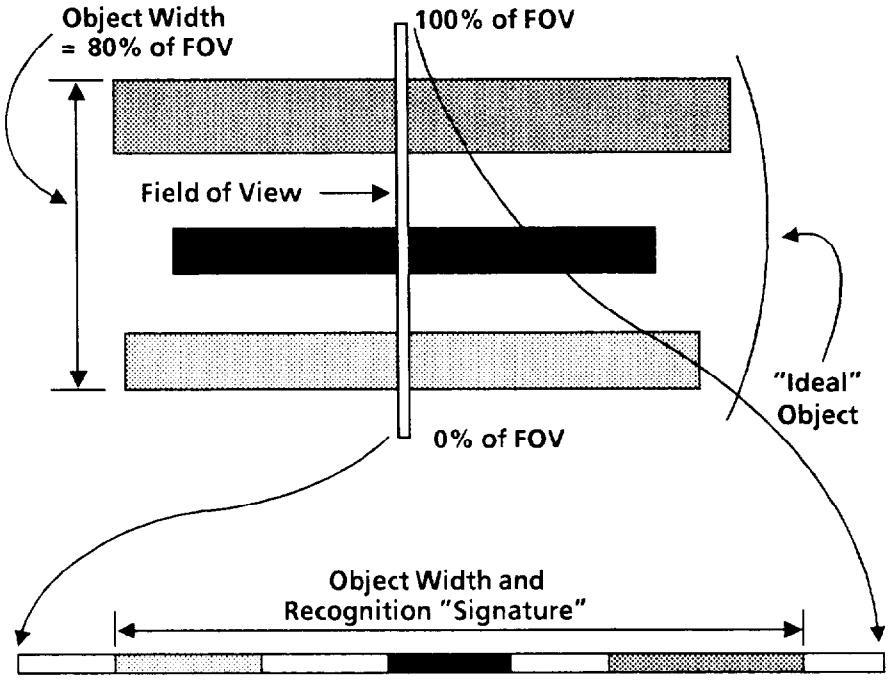
During operation in the run mode, the SLS compares the signature of an inspected object (regardless of its *position* along the FOV) with the stored signature of the ideal object, and reports the results of this comparison as the *percentage of match* of the two signatures. These results appear on the Analog A output.

When the inspected object is *exactly* the same as the ideal object, the percentage of match is 100%. When something in the inspected object is *not* the same (such as one of the component objects is a different shade of gray or is missing), the percentage of match is *less* than 100%. How *much* less depends on the magnitude of the change.

NOTE: The inspected objects must be consistently fixtured during both the setup/teach mode and the run mode so that they always have the same orientation in the FOV. Also, the lighting must be consistent in both position and intensity.

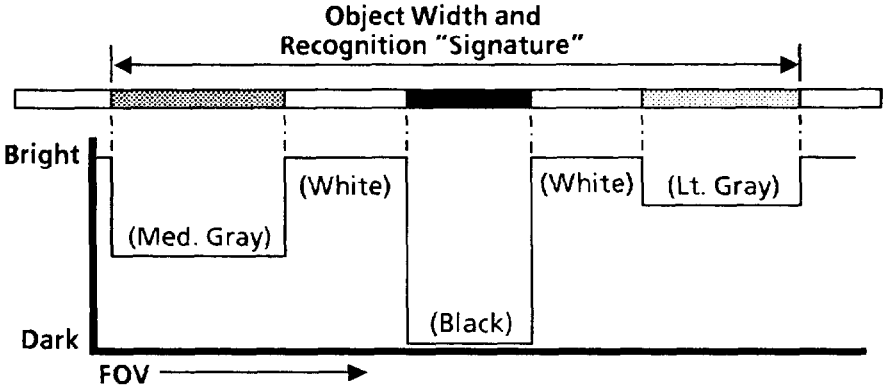
The object width results appear on the Analog B output. (The term "object width" has the same meaning here as it does for the *Object Width Measurement* function.)

In the illustration below, the SLS "sees" the three *separate* objects in the FOV as one *composite* object with gray scale variations.



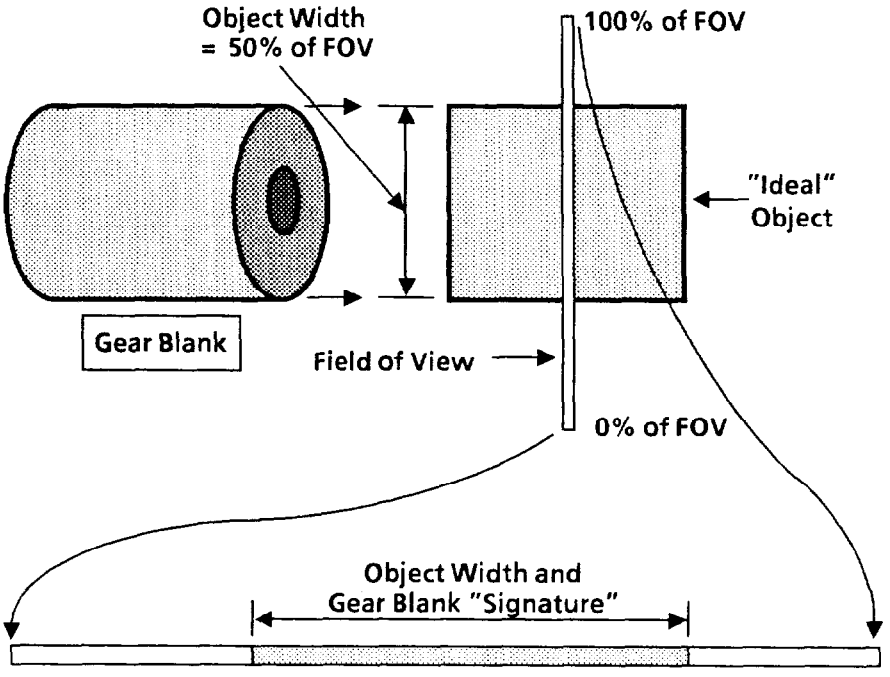
1-D Object Recognition (continued)

The following illustration is a *graphical* depiction of the shades of gray within the preceding recognition signature.



Example #1: In this example, the SLS uses the *1-D Object Recognition* function to inspect uncut gear "blanks" on a gear-grinding machine. The main purpose of the inspection is to determine whether a gear blank is acceptable for grinding. Another purpose is to determine whether a finished gear has somehow remained on the grinder. If so, action would be necessary to prevent the grinder from operating on the finished gear and damaging both the gear and the cutter.

In the illustration below, the SLS "learns" the signature of an ideal gear blank during the setup/teach mode, as follows:



During the run mode, the SLS compares the signature of each inspected object with the stored recognition signature of the ideal object.

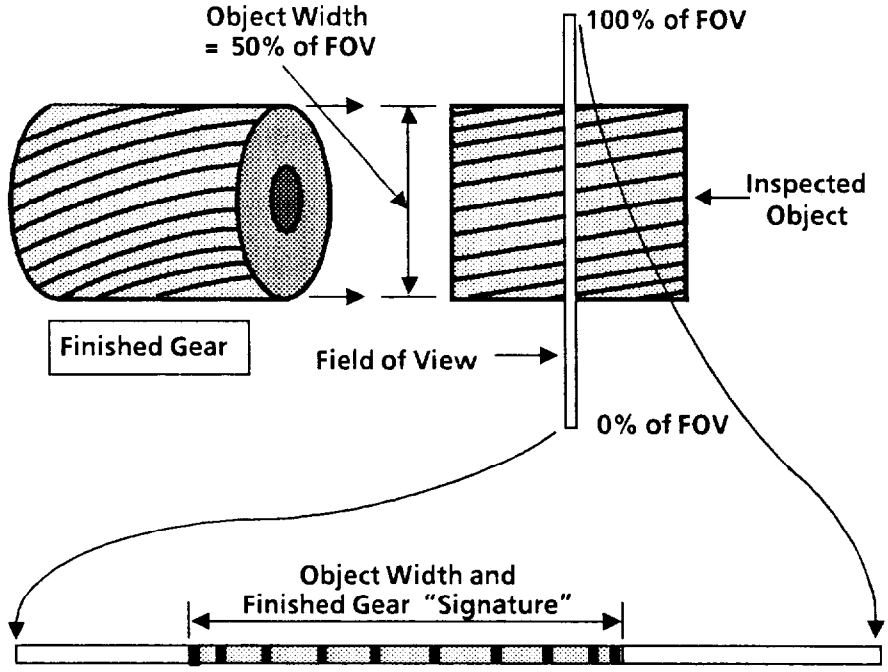
1-D Object Recognition (continued)

For this example, assume that the *first* inspected object is a gear blank (not a finished gear), its signature *is* like the *stored* signature (the gear blank is not flawed in shape or appearance), and the *percentage of match* is 85%.

At the Analog A output, the current is 85% of the difference between 4mA and 20mA, or 17.6mA. As a consequence, the grinding equipment is instructed to perform its cutting operation on the gear blank.

At the Analog B output, the current reflects the object width, which is 50% of the FOV. This becomes 50% of the difference between 4mA and 20mA, or 12mA.

Now, assume that the *second* inspected object is a finished gear that somehow remained in the cutting fixture. In this case, the gear's signature is *not* like the stored signature.



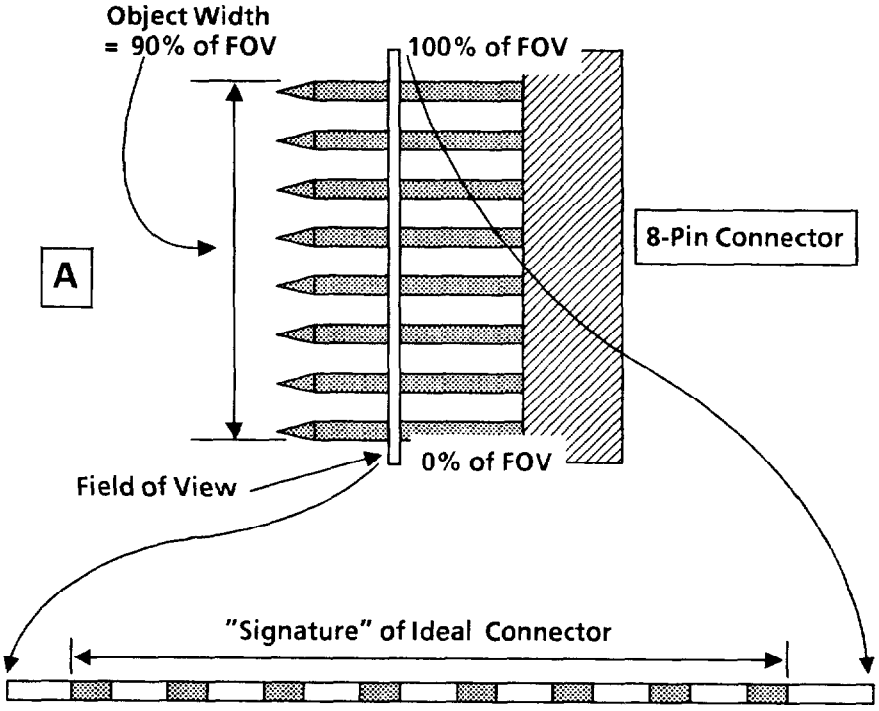
Since the gear's signature is not like the stored signature, the percentage of match is now 30%.

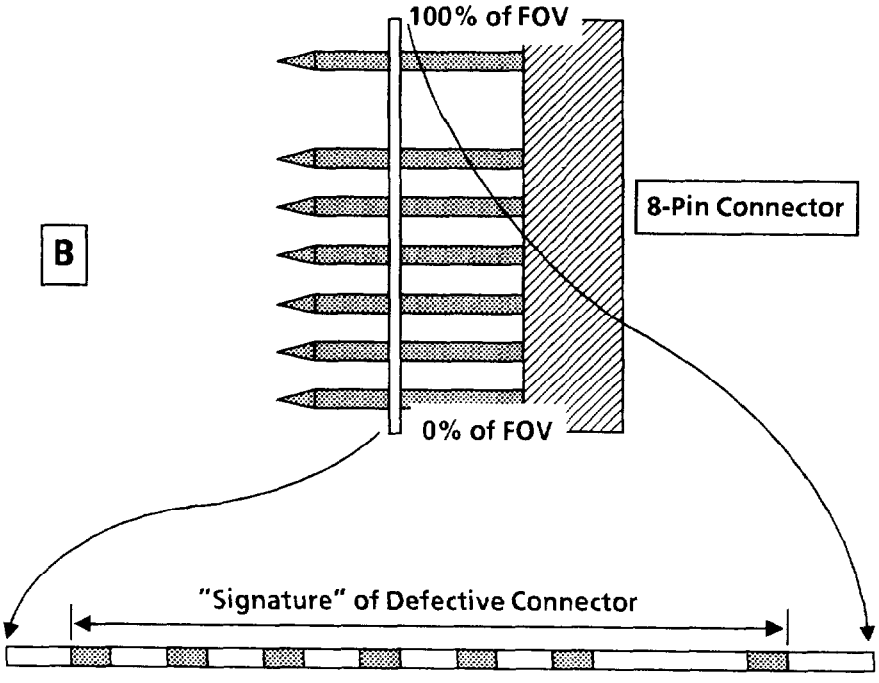
At the Analog A output, the current is 30% of the difference between 4mA and 20mA, or 8.8mA. As a consequence, the grinding equipment is *not* be instructed to cut the gear, thereby averting likely damage to both the gear and the cutting wheel.

At the Analog B output, the current *remains* 50% of the difference between 4mA and 20mA, or 12mA.

1-D Object Recognition (continued)

Example #2: In this example, the SLS uses the *1-D Object Recognition* function to inspect the pins on an 8-pin connector and verify that all eight pins are in place. If the pins are all there, the connector will be allowed to continue to the next assembly process; if not, the connector will be rejected.





1-D Object Recognition (continued)

During the setup/teach mode, the SLS "learns" the signature of a representative ("ideal") sample of the 8-pin connector, on which all eight pins are in their proper positions and are intact.

In the preceding illustration, **A** shows the "ideal" connector and its signature, which the SLS learns during the setup/teach mode. During the run mode, this connector, and all connectors like it, should result in a *high* percentage of match, such as 85%.

At the Analog A output, the current is 85% of the difference between 4mA and 20mA, or 17.6mA. As a consequence, the process equipment is instructed to *accept* the connector and pass it to the next process stage.

At the Analog B output, the current reflects the object width, which is 90% of the FOV. This becomes 90% of the difference between 4mA and 20mA, or 18.4mA.

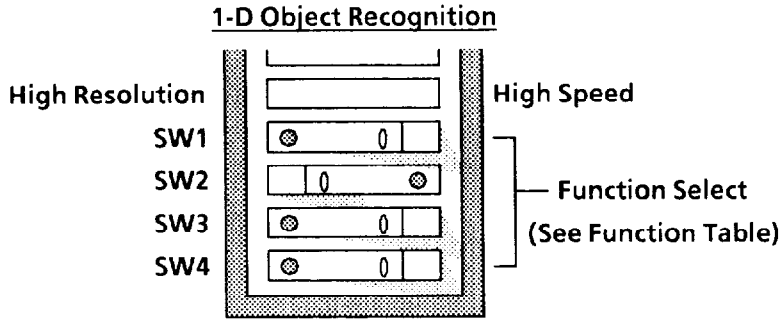
In the same illustration, **B** shows a "bad" connector and the corresponding signature. Since this connector's signature is not like the stored signature, it should result in a *low* percentage of match, such as 15%.

At the Analog A output, the current is 15% of the difference between 4mA and 20mA, or 6.4mA. As a consequence, the process equipment is instructed to *reject* this connector.

At the Analog B output, the current remains 90% of the difference between 4mA and 20mA, or 18.4mA.

Use the following steps to configure the SLS for the *1-D Object Recognition* function.

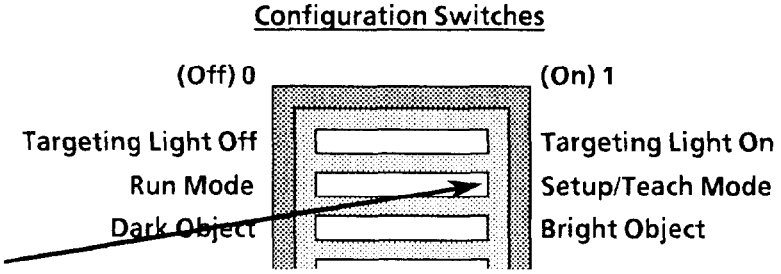
Your Action	Comments
Set the lower four function switches as shown.	SW1, SW3, and SW4 must be *off* and SW2 must be *on* to enable the *1-D Object Recognition* function.



Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

1-D Object Recognition (continued)

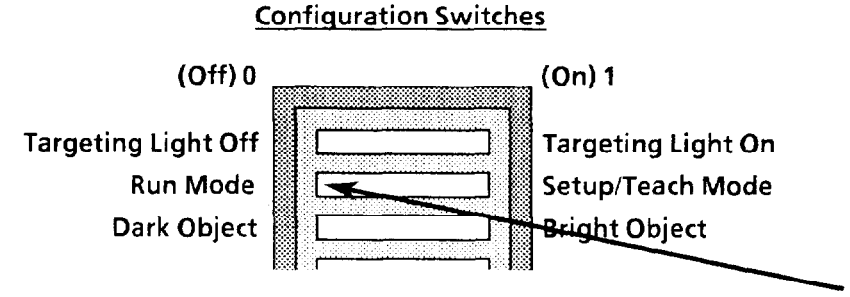
Set the operating mode switch to Setup/Teach Mode.



The SLS "learns" the lighting compensation parameters and the object's signature in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn these parameters.

After a few seconds (or 10 to 20 image acquisitions), set switch to Run Mode.

The SLS saves the lighting compensation parameters and object signature.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

Included-Object Texture Recognition

This analysis function requires at least *one* object lying *wholly* within the FOV. When *two* or more objects appear in the FOV, the SLS interprets them as *one* object, from the first edge of the first object to the last edge of the last object.

Using the *Included-Object Texture Recognition* function, the SLS compares the texture "frequency" pattern of an *ideal* object (stored in its memory) with the texture pattern of each inspected object. These texture patterns are the recognition "signatures" of the two objects.

Included-Object Texture Recognition (continued)

NOTE: In order to determine the *feasibility* of your application, you must be sure that the SLS can "see" the texture on your inspected objects. The only way to be sure of that is to use the SLS Configuration Support Software and observe the View Image display of your object. *If the texture is not visible in the display, your application is not feasible.*

During the setup/teach mode, the SLS "learns" the texture "frequency," or granular characteristic, of the ideal object's surface. This is the "recognition signature." At the start of the run mode, the SLS stores the recognition signature in its memory.

During operation in the run mode, the SLS compares the signature of an inspected object (regardless of its *position* along the FOV) with the stored signature of the ideal object, and reports the results of this comparison as the *percentage of match* of the two signatures. These results appear on the Analog A output.

When the inspected object is *exactly* the same as the ideal object, the percentage of match is 100%. When something in the inspected object is *not* the same (such as a flaw in the surface texture), the percentage of match is *less* than 100%. How *much* less depends on the size of the flaw.

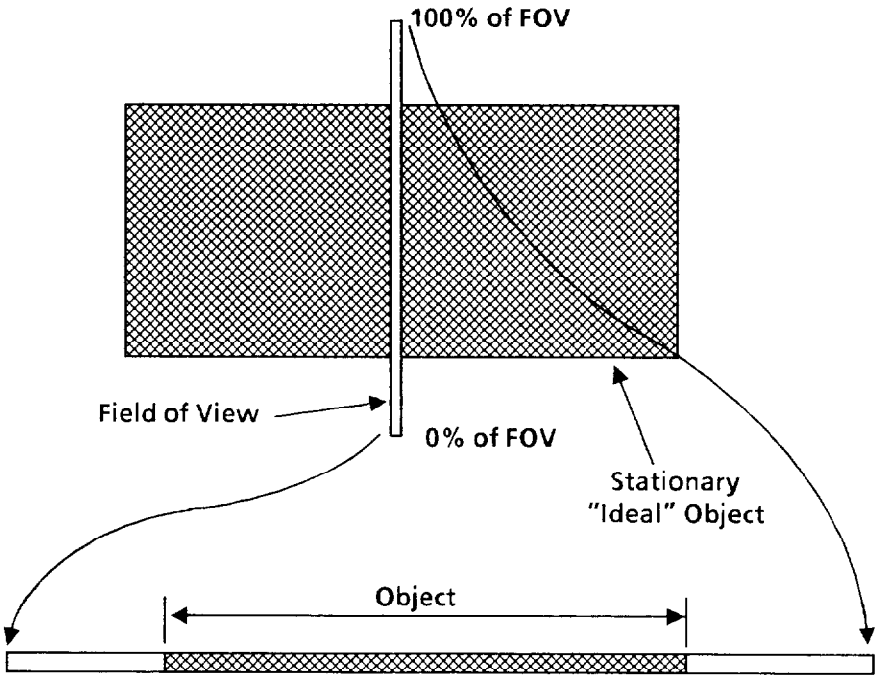
The SLS also uses the *Included-Object Texture Recognition* function to measure the width between the first and last edges of the object. The object width results appear on the Analog B output.

Before the SLS learns the recognition signature of the ideal object, it must learn lighting compensation parameters using the *1-D Spatial Measurement* function. With the ideal object positioned within the FOV (as shown in the first illustration on the next page), and the operating mode switch set to "setup/teach," the SLS learns the lighting compensation parameters within a few seconds (10 to 20 image acquisitions).

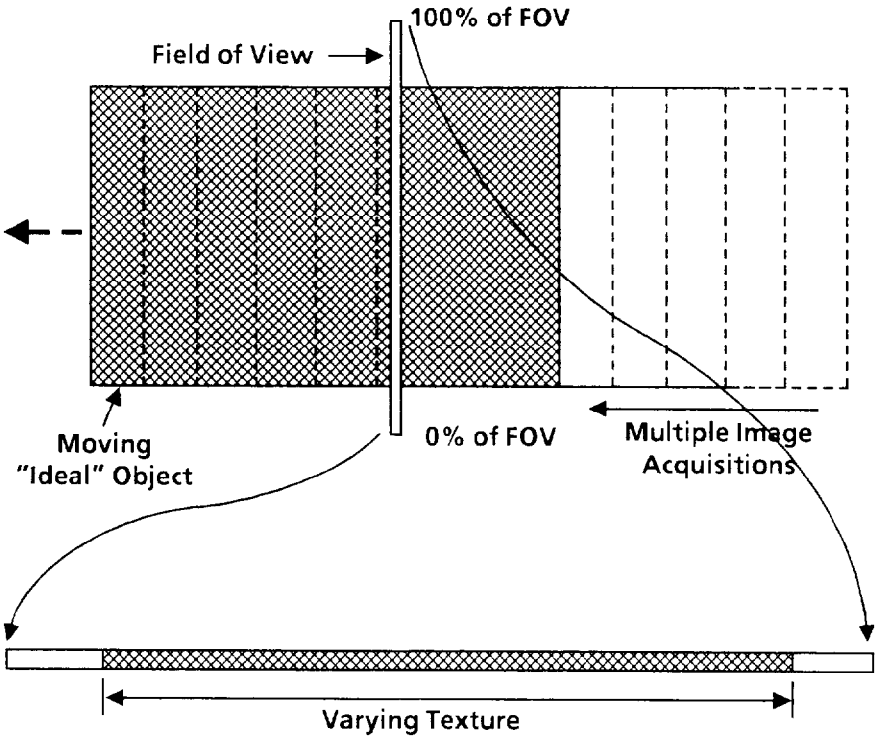
When the operating mode switch is set to "run," the SLS *saves* the lighting compensation parameters in its memory.

The analysis function switches are then be changed to the *Included-Object Texture Recognition* function. The ideal object remains in the FOV.

Included-Object Texture Recognition (continued)



With the operating mode switch set to "setup/teach," an ideal object (such as a strip of coarse sandpaper) is moved across the FOV, as shown in the illustration below.



Included-Object Texture Recognition (continued)

The SLS learns the recognition signature by acquiring images of the texture at several points along the object, and thus "seeing" several slight variations of the "ideal" texture.

NOTE: You can determine the proper number of image acquisitions by trial and observation. In general, if too *many* images are acquired, the SLS may fail to indicate real flaws; if too *few* images are acquired, the SLS may indicate flaws where none exist.

Example: In this example, the SLS uses the *Included-Object Texture Recognition* function to inspect a continuous sheet of coarse sandpaper for flaws, such as areas on which the "sand" granules did not adhere to the paper.

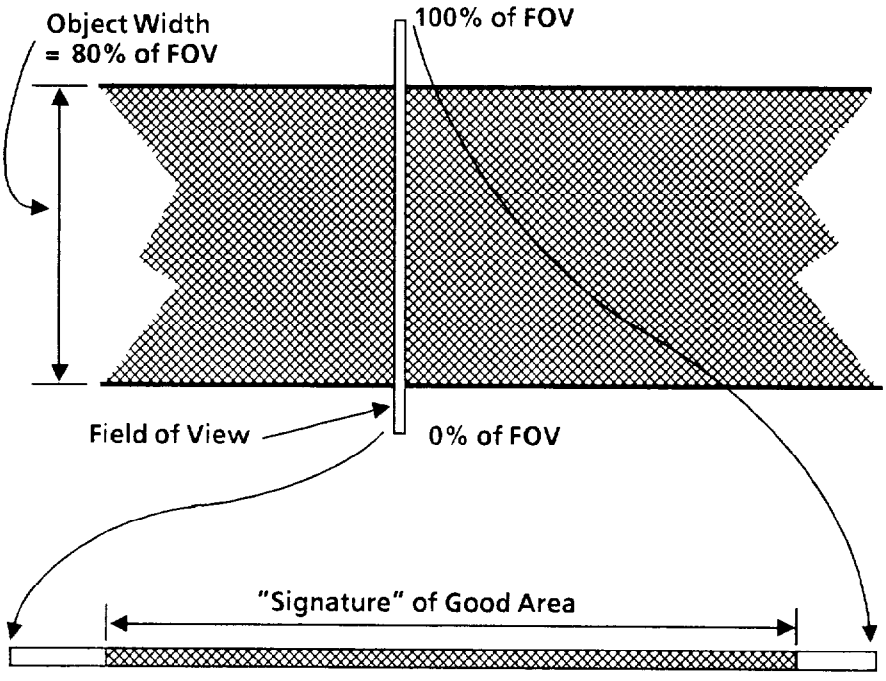
During the setup/teach mode, the SLS learns the signature of *good* texture on the sandpaper. To accomplish this, you must set up the SLS to acquire images of the sandpaper at several points along its length.

During run mode operations, the SLS inspects the sheet at close intervals. For this example, assume that all areas with good texture result in a *percentage of match* of 85%.

At the Analog A output, the current in this case is 85% of the difference between 4mA and 20mA, or 17.6mA. As a consequence, the process equipment is instructed to *continue* the processing of the sandpaper.

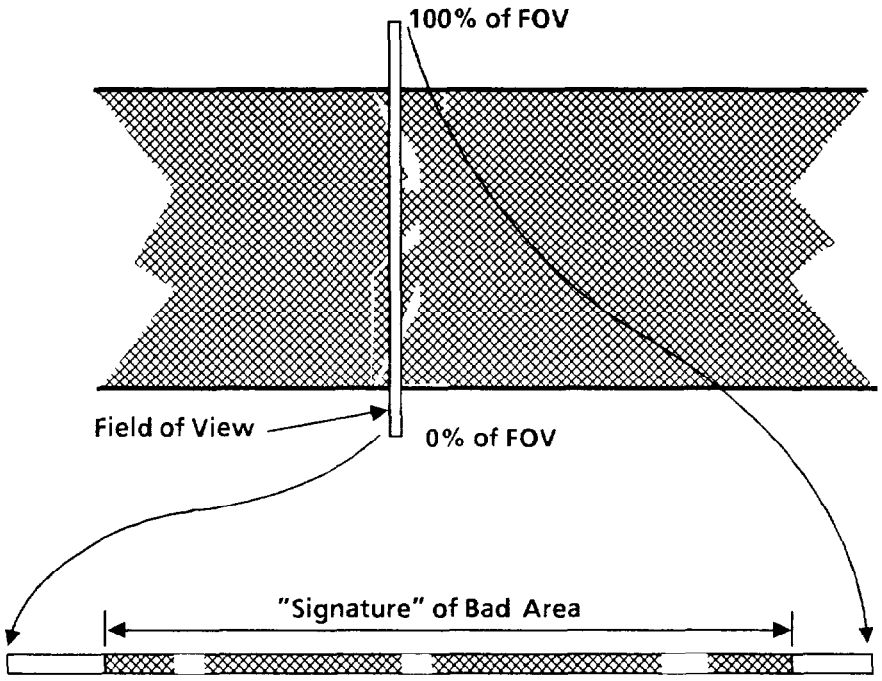
At the Analog B output, the current reflects the object width, which is 80% of the FOV. This becomes 80% of the difference between 4mA and 20mA, or 16.8mA.

The illustration below shows the "good" texture and its signature, which the SLS learns during the setup/teach mode.



Included-Object Texture Recognition (continued)

The next illustration shows flaws in the sandpaper and in the corresponding signature. Since the flawed signature is *not* like the stored signature, it should result in a *low* percentage of match, such as 50% in this example.



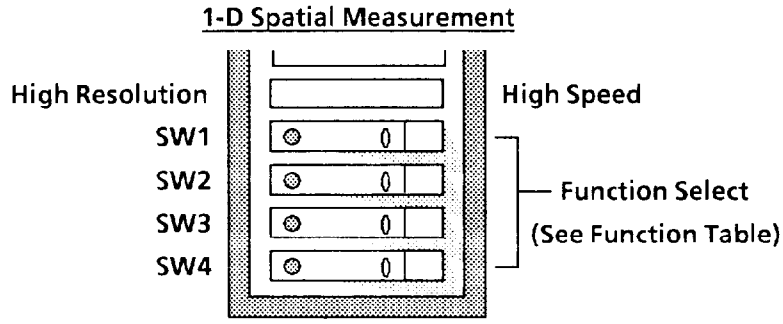
At the Analog A output, the current in this case is 50% of the difference between 4mA and 20mA, or 12.0mA. As a consequence, the process equipment is instructed to *stop* the processing so that the cause of the flaws can be determined and corrected.

At the Analog B output, since the object's width remains unchanged, the current remains 80% of the difference between 4mA and 20mA, or 16.8mA.

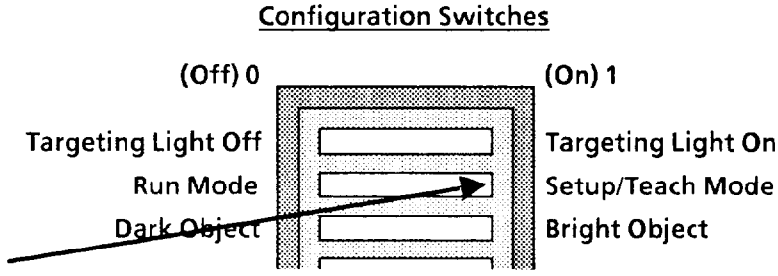
Included-Object Texture Recognition (continued)

Use the following steps to configure the SLS for the *Included-Object Texture Recognition* function. Assume that the SLS is already staged for its application and is powered up, and the "ideal" object is properly positioned in the FOV. Assume also that you have used the SLS Configuration Support Software and have determined that your application *is* feasible.

Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW4 must be *off* to enable the *1-D Spatial Measurement* function.



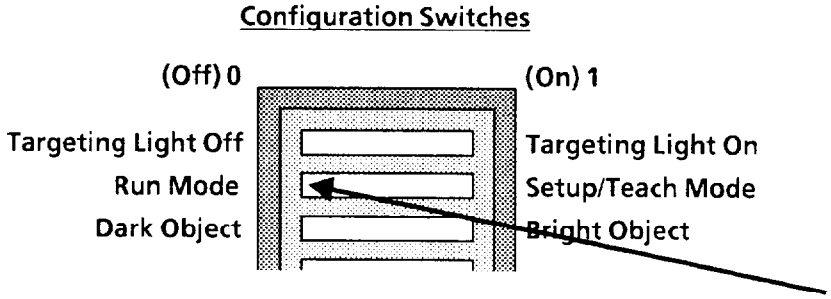
Set these "mode" switches as required for your application.	Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.
Set the operating mode switch to Setup/Teach Mode.	



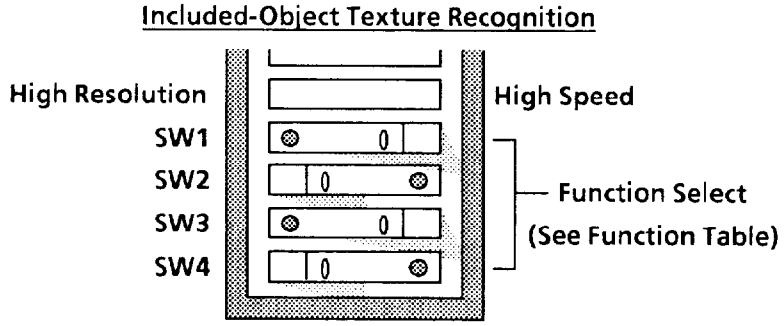
The SLS "learns" the lighting compensation parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

Included-Object Texture Recognition (continued)

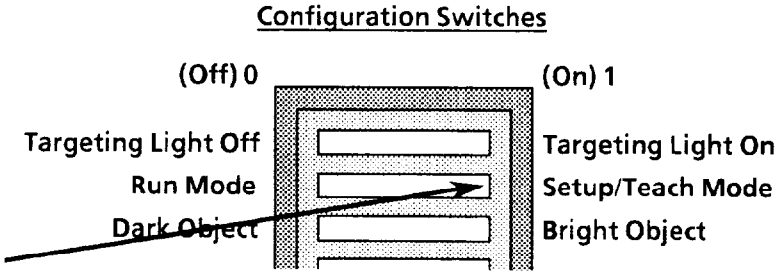
Your Action	Comments
After a few seconds (or 10 to 20 image acquisitions), set the switch to Run Mode.	The SLS saves the lighting compensation parameters.



Set the lower four function switches as shown.	SW1 and SW3 must be *off* and SW2 and SW4 must be *on* to enable the *Included-Object Texture Recognition* function.



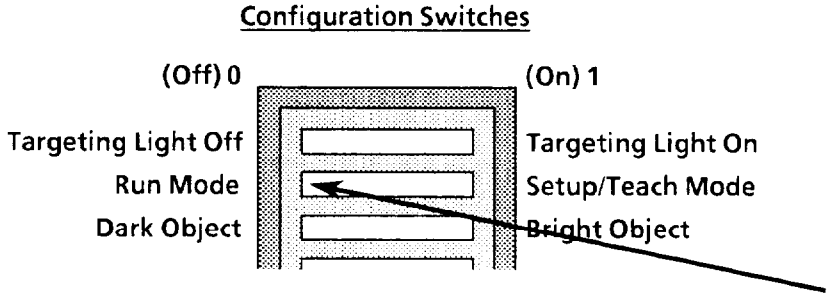
Set the operating mode switch to Setup/Teach Mode.	



Begin moving the object slowly across the FOV to enable the SLS to learn the recognition signature.	The SLS learns the recognition signature of the "ideal" object by acquiring images at several points along its length. **NOTE:** As previously discussed, you can determine the proper number of images to acquire by trial and observation.

Included-Object Texture Recognition (continued)

Your Action	Comments
When the SLS has learned the object signature, set the switch to Run Mode.	The SLS saves the object signature.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

Full-Field Texture Recognition

This analysis function does *not* require an "object" – that is, an identifiable first and last edge – to lie wholly *within* the FOV. Instead, the SLS assumes that the entire FOV is occupied *fully* with the surface texture of the object to be inspected.

The *Full-Field Texture Recognition* function does *not* perform an object width measurement. Beyond that, this function operates the same as the *Included-Object Texture Recognition* function.

Using the *Full-Field Texture Recognition* function, the SLS compares the texture "frequency" of an *ideal* object with the texture frequency of the object currently in the FOV. These patterns are the recognition "signatures" of the two objects.

NOTE: In order to determine the *feasibility* of your application, you must be sure that the SLS can "see" the texture on your inspected objects. The only way to be sure of that is to use the SLS Configuration Support Software and observe the View Image display of your object. *If the texture is not visible in the display, your application is not feasible.*

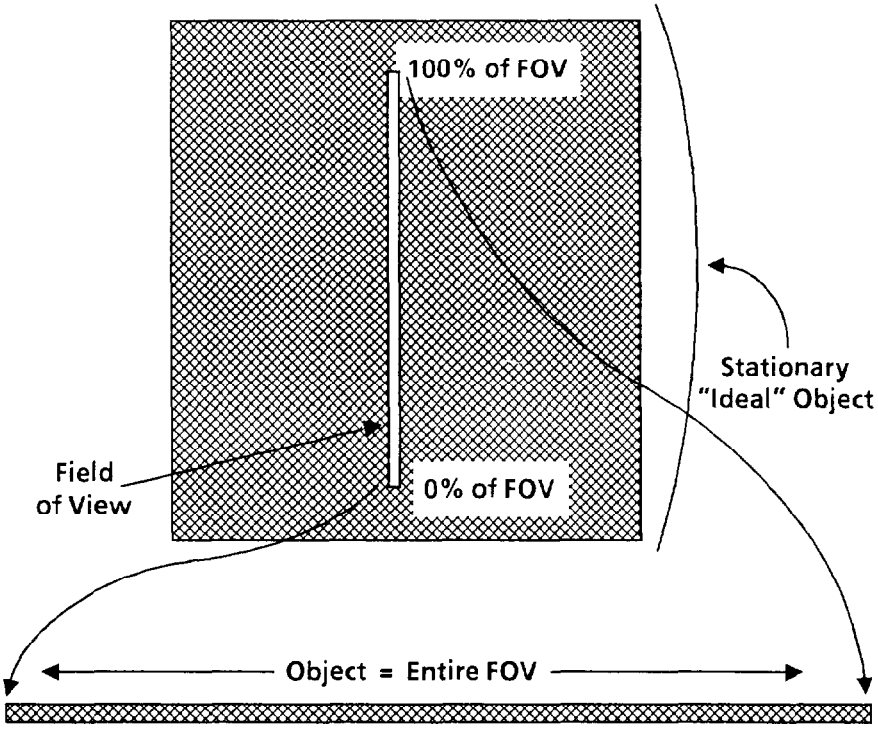
During the setup/teach mode, the SLS "learns" the texture "frequency," or granular characteristic, of the ideal object's surface. This is the "recognition signature." At the start of the run mode, the SLS stores the recognition signature in its memory.

Full-Field Texture Recognition (continued)

During operation in the run mode, the SLS compares the signature of an inspected object (regardless of its *position* along the FOV) with the stored signature of the ideal object, and reports the results of this comparison as the *percentage of match* of the two signatures. These results appear on the both the Analog A and B outputs.

When the inspected object is *exactly* the same as the ideal object, the percentage of match is 100%. When something in the inspected object is *not* the same (such as a flaw in the surface texture), the percentage of match is *less* than 100%. How *much* less depends on the size of the flaw.

Before the SLS learns the recognition signature of the ideal object, it must learn lighting compensation parameters using the *1-D Spatial Measurement* function. With the FOV positioned over the ideal object, as shown in the following illustration, and the operating mode switch set to "setup/teach," the SLS learns the lighting compensation parameters within a few seconds (10 to 20 image acquisitions).

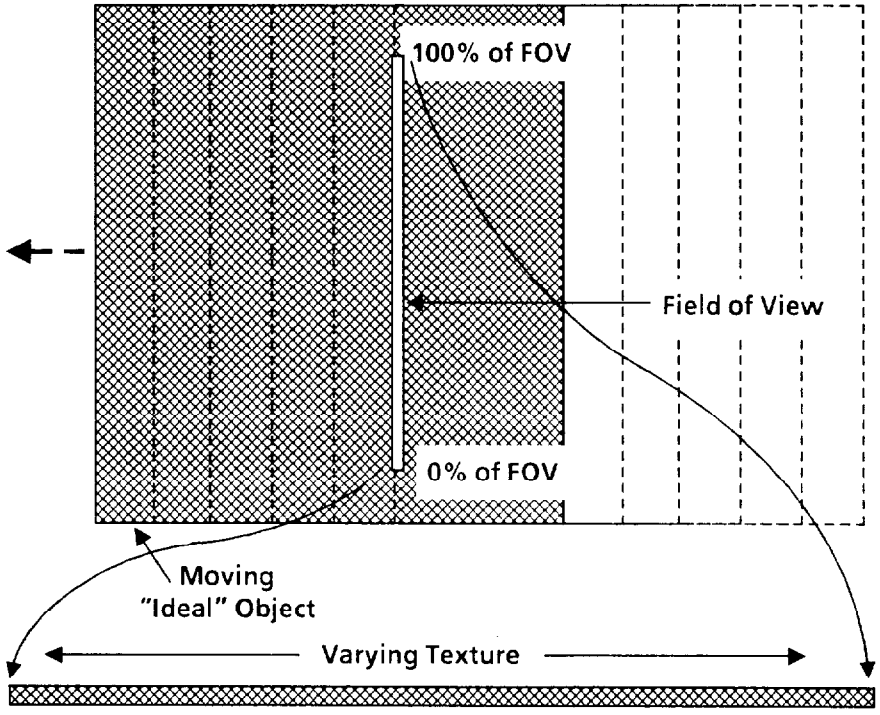


When the operating mode switch is set to "run," the SLS *saves* the lighting compensation parameters in its memory.

The analysis function switches are then be changed to the *Full-Field Texture Recognition* function. The ideal object remains in the FOV.

Full-Field Texture Recognition (continued)

With the operating mode switch set to "setup/teach," an ideal object (such as a strip of coarse sandpaper) is moved across the FOV, as shown in the illustration below.



The SLS learns the recognition signature by acquiring images of the texture at several points along the object, and thus "seeing" several slight variations of the "ideal" texture.

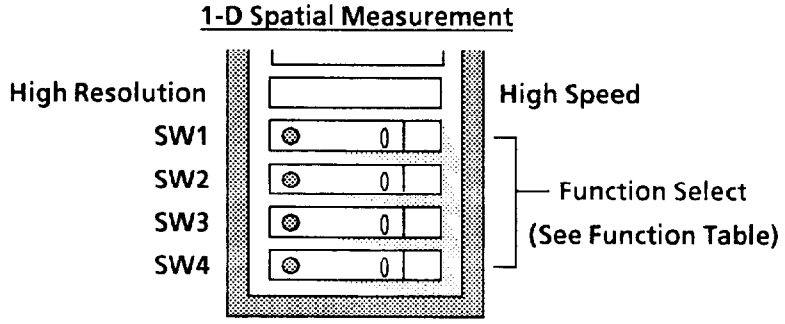
NOTE: You can determine the proper number of image acquisitions by trial and observation. In general, if too *many* images are acquired, the SLS may fail to indicate real flaws; if too *few* images are acquired, the SLS may indicate flaws where none exist.

Example: Refer to the example in the discussion of the *Included-Object Texture Recognition* function.

Full-Field Texture Recognition (continued)

Use the following steps to configure the SLS for the *Full-Field Texture Recognition* function. Assume that the SLS is already staged for its application and is powered up, and the "ideal" object is properly positioned in the FOV. Assume also that you have used the SLS Configuration Support Software and have determined that your application *is* feasible.

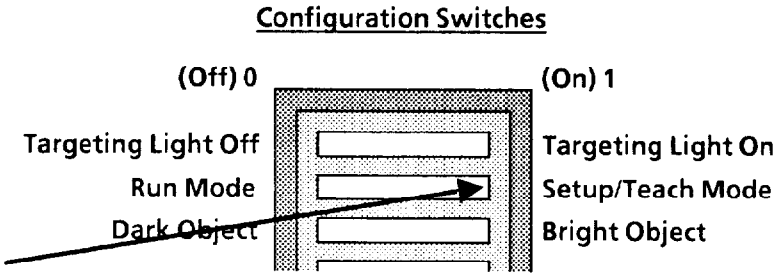
Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW4 must be *off* to enable the *1-D Spatial Measurement* function.



Set these "mode" switches as required for your application.

Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

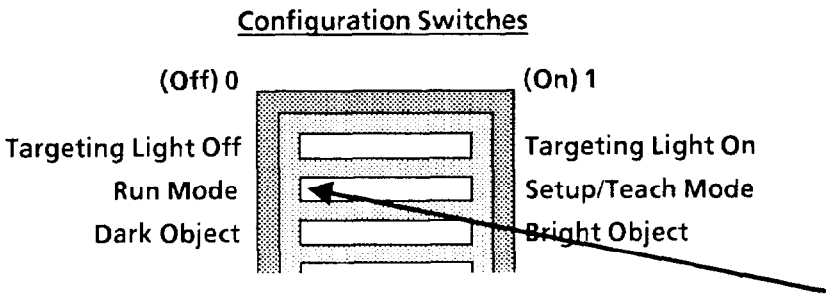
Set the operating mode switch to Setup/Teach Mode.



The SLS "learns" the lighting compensation parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

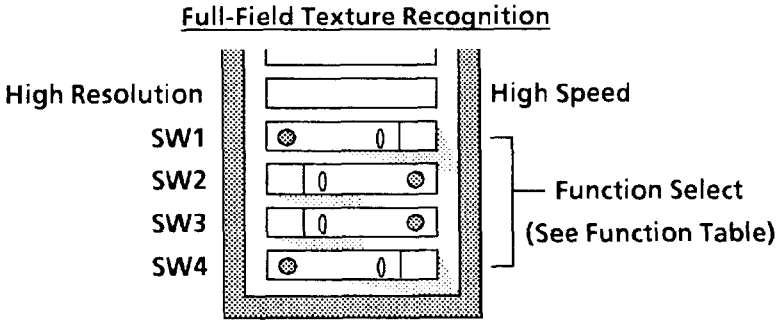
Full-Field Texture Recognition (continued)

Your Action	Comments
After a few seconds (or 10 to 20 image acquisitions), set the switch to Run Mode.	The SLS saves the lighting compensation parameters.

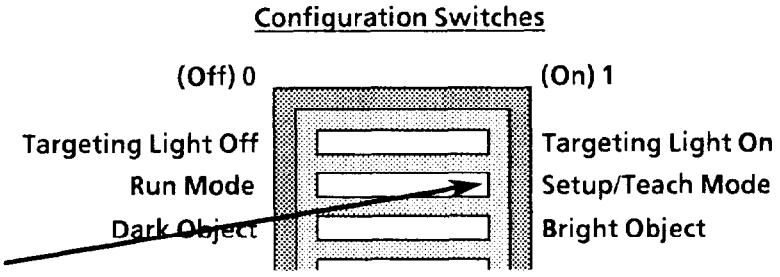


Set the lower four function switches as shown.

SW1 and SW4 should be *off* and SW2 and SW3 should be *on* to enable the *Full-Field Texture Recognition* function.



Set the operating mode switch to Setup/Teach Mode.



Begin moving the object slowly across the FOV to enable the SLS to learn the recognition signature.

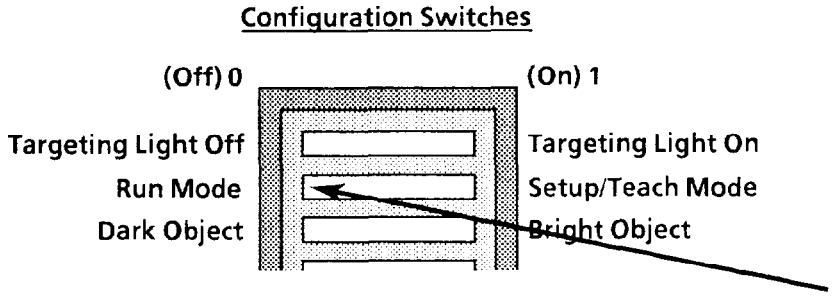
The SLS learns the recognition signature of the "ideal" object by acquiring images at several points along its length.

NOTE: As previously discussed, you can determine the proper number of images to acquire by trial and observation.

Full-Field Texture Recognition (continued)

When the SLS has learned the recognition signature, set the switch to Run Mode.

The SLS saves the recognition signature.



The SLS can now begin operating in the run mode, during which it acquires images (according to the trigger mode setting), analyzes these images, and sends the results to the analog and discrete outputs.

Binary Object Size Binary Object Count

These analysis functions are available only in the Series B SLS when it is connected to a personal computer using the Series B SLS Configuration Support Software (CSS). The functions are mentioned here for reference only. (If either function is selected *without* using the CSS, the SLS performs a "null" function and flashes the error LED continuously.)

These two functions provide an adjustable binary threshold that can be used to "mask off" unwanted visual clutter in the FOV. This enables the SLS to ignore everything in the FOV *below* the binary threshold, and to look for the inspected objects only in the area *above* the threshold.

After the SLS has been configured with one of the binary object functions, the binary threshold can be adjusted using the View Image option (the Configure option version) in the CSS. When the proper threshold setting has been achieved, it is transferred to the appropriate configuration record for subsequent downloading to the SLS.

The *Binary Object Size* function measures the *cumulative* size of all objects (dark *or* light, whichever is selected) in the FOV. Thus, if three dark objects are in the FOV, and they measure 15%, 20%, and 25% of the FOV, the SLS returns a binary object size of 60%.

The *Binary Object Count* determines the number of objects (dark *or* light, whichever is selected) within the FOV. The outputs reflect the object count on the basis of a *fixed maximum* of 50. Thus, if 10 objects are in the FOV, the SLS returns an object count of 20%.

Parts Counting

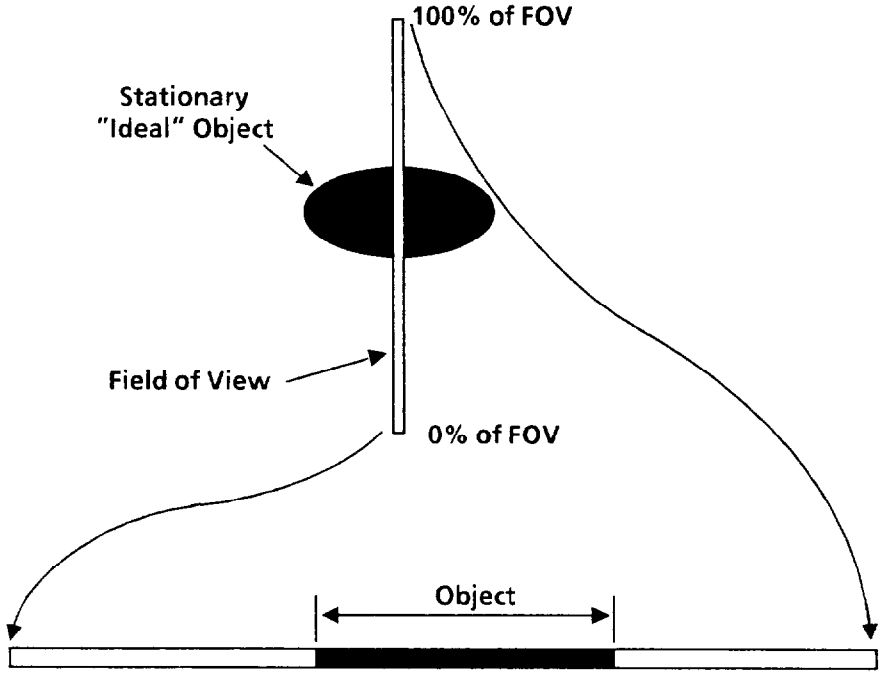
This analysis function enables the SLS to count objects ("parts") moving on a conveyor belt, or similar device. Two or more objects can be in the FOV at the same time, but cannot contact each other. The SLS must be positioned so that the FOV spans the conveyor at right angles to the direction of movement.

Two function switch settings are required: One is for teaching the parts counting parameters, and the other is for performing the actual parts counting.

During the *Parts Counting: Teach* function, the SLS "learns" the object size and the object-count number by acquiring multiple images as the object moves across the FOV at right angles. At this time, the Analog A output remains a 4mA. The Analog B output indicates the object's width at the instant of each image acquisition; thus, it is likely to change as the object moves across the FOV.

During the *Parts Counting: Run* function, when inspected objects move across the FOV, the SLS counts each object and reports the *cumulative* count "result" as a *percentage of the maximum count* on both analog outputs.

Before the SLS learns the parts counting parameters, it must learn lighting compensation parameters using the *1-D Spatial Measurement* function. With the ideal object positioned in the FOV as shown in the illustration below, and the operating mode switch set to "setup/teach," the SLS learns the lighting compensation parameters within a few seconds (10 to 20 image acquisitions).



When the operating mode switch is set to "run," the SLS *saves* the lighting compensation parameters in its memory.

Parts Counting *(continued)*

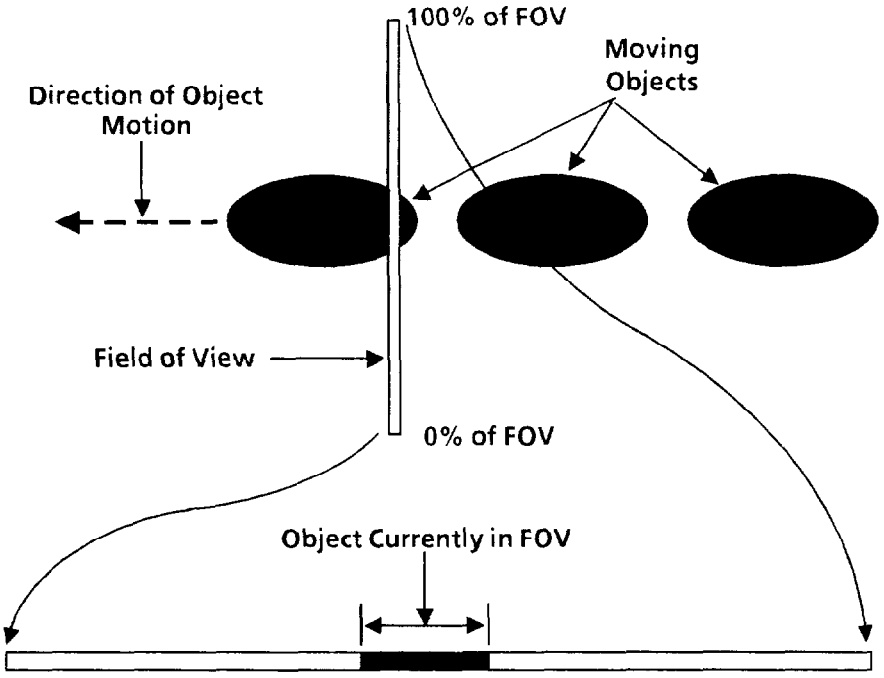
The analysis function switches are then be changed to the *Parts Counting: Teach* function, and the ideal object removed from the FOV.

Teach Function – The *Parts Counting: Teach* function is a separate function-switch setting whose purpose is to enable the SLS to "learn" the object size and the number of objects to be counted.

NOTE 1: During the Teach function, the *spacing* of the image acquisitions must be consistent.

Thus, if the conveyor moves at an *unvarying* speed, the SLS trigger mode switch can be set to *Level Triggered*, which enables the SLS to acquire images at its maximum rate. If the conveyor speed *varies*, however, the trigger mode switch should be set to *Edge Triggered* and the trigger signals synchronized with the conveyor.

In the following illustration, the specified number of objects are shown moving single file across the FOV.



NOTE 2: The *first* object to cross the FOV must be the "ideal" object. The SLS learns this object's size, then records it at 50% of its *actual* size. This enables the SLS to accept size variations of ±50% from the size of the ideal object.

NOTE 3: *All* objects must cross the FOV *single file*, and they must be spaced far enough apart for the SLS to acquire at least *one* image in the gap between objects *at the applicable rate of movement.*

Parts Counting *(continued)*

The Teach function is complete when the specified number of objects have passed completely across the FOV. At this point, you must set the function switches to the *Parts Counting: Run* function.

Run Function – The *Parts Counting: Run* function is a separate function-switch setting whose purpose is to enable the SLS to count the specified number of "learned" objects.

During the Run function, the SLS counts objects passing through the FOV. The size of an object must be within ±50% of the size of the ideal object to be included in the count. Otherwise, the SLS will ignore the object.

For each object that the SLS counts, it increments the analog outputs by the percent that the single object bears to the number taught. For example, if the number of objects taught were 12, the analog output current would increase by 8.33% for each object counted ($1 \div 12 = 0.0833$; $0.0833 \times 100 = 8.33\%$).

Using Edge Triggered Mode: When the SLS is counting parts while operating in the edge triggered mode, the trigger signals must be synchronized with the conveyor.

The SLS restarts the parts count when the next object crosses the FOV after the maximum count is reached (and the outputs reach 100%). For example, if the "learned" maximum count were 20, the SLS would restart the parts count after the 21st object crossed the FOV. Thus, the SLS would count the 21st object as the *first* object of the next lot, and the outputs would indicate 5%.

This capability is useful in an application that count objects to be placed in a package, where the lot size must always equal the maximum count.

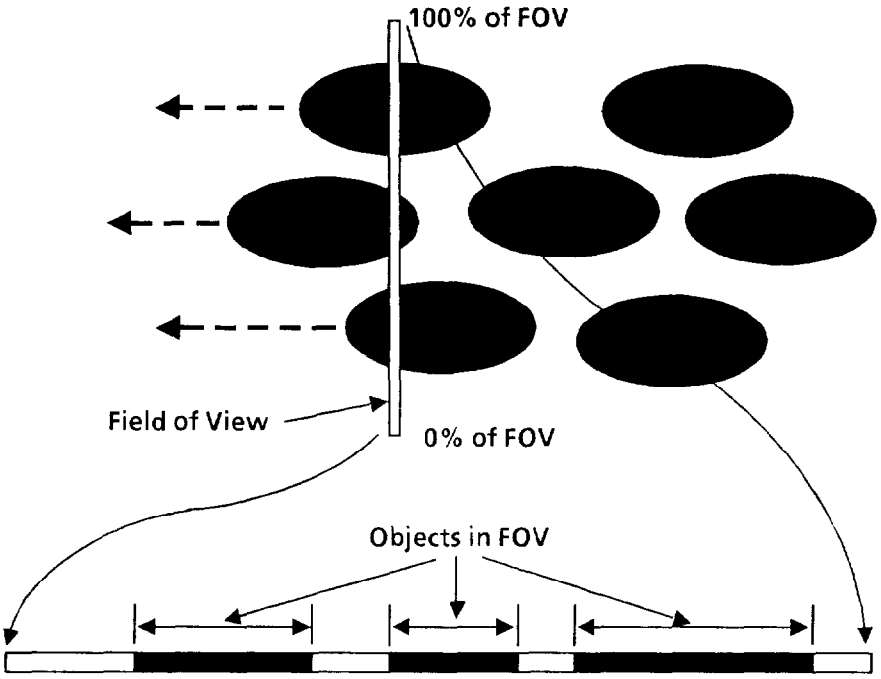
Using Level Triggered Mode: When the SLS is counting parts while operating in the level triggered mode, the conveyor must be moving at a predictable, uniform speed.

The SLS can restart the part count when the trigger input rises momentarily before the next object enters the FOV. For example, if the "learned" maximum count were 10, and the trigger input rose momentarily after the 5th object crossed the FOV, the SLS would restart the part count after the 6th object crossed the FOV. Thus, the SLS would count the 6th object as the *first* object of the next lot, and the outputs would indicate 10%.

This capability can be useful in an application that counts objects in a package to determine whether the *correct* number of objects (that is, the "taught "count) is present.

Parts Counting *(continued)*

The following illustration shows you how the SLS performs the *Parts Counting: Run* function.



The specified number of objects are shown moving as a group across the FOV. When an object enters the FOV, the SLS keeps track of it, and does not count the object until it leaves the FOV.

The gap between successive objects must be sufficient for the SLS to acquire at least one image in the gap. To accomplish this, the conveyor speed and distance between the objects and the SLS must be considered.

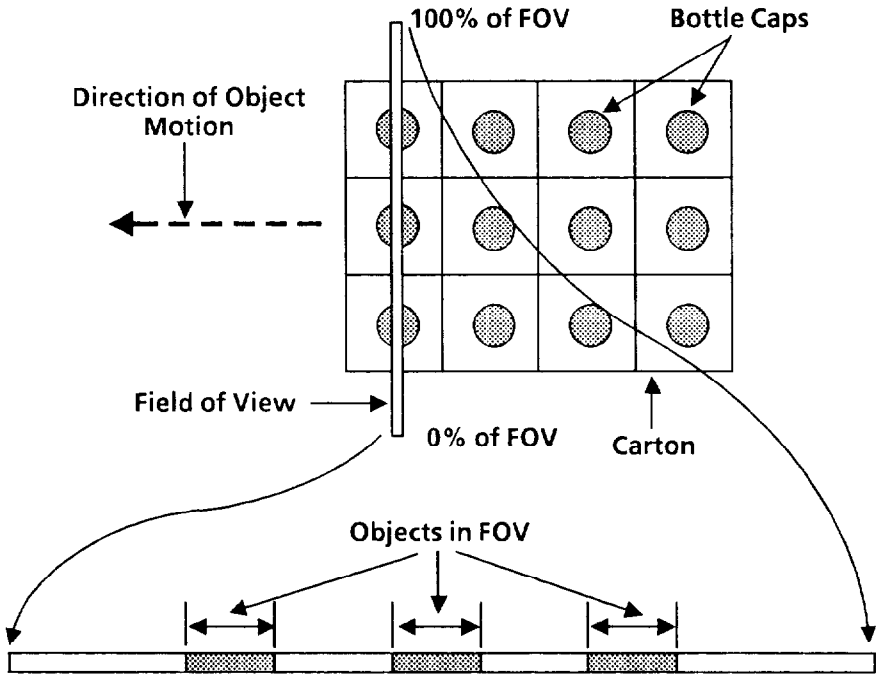
The objects' rate of movement during the Run function must be the same as their rate during the Teach function, unless synchronized triggering is used, as mentioned earlier.

Note that more than one object can occupy the FOV at any given time. The spacing must be sufficient for the SLS to acquire at least *one* image in the gap between objects *at the applicable rate of movement.*

Parts Counting (continued)

Example: Here is an example application that uses the parts counting function to count bottles in a carton. The objective is to determine whether the carton has 12 bottles in it by counting the bottle caps. If not, the process equipment rejects the carton and resets the SLS part count

Since the SLS part count must be *reset* when a short count occurs, this example requires level triggering and, consequently, requires a constant-speed conveyor system.



During the Teach function, the SLS "learns" the size of an individual bottle cap and the count number, 12.

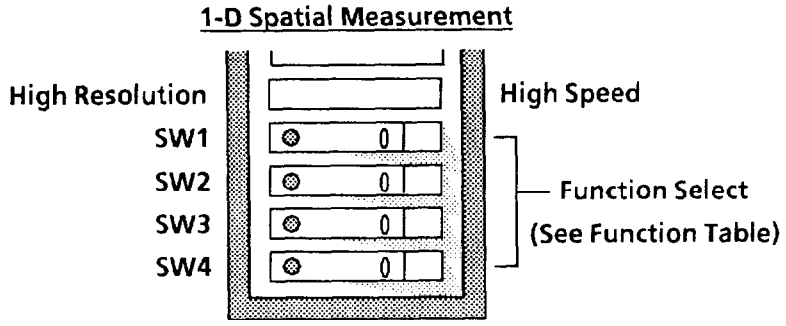
During the Run function, the SLS counts three objects at one time. Thus, when the first three bottle caps cross the FOV, the analog output current increases by 25% of the difference between 4mA and 20mA, to 8mA. When the second three caps cross the FOV, the current increases to 12mA. This continues until all 12 bottle caps have crossed the FOV, and the current is 20mA.

If one bottle were *missing*, the cumulative current would be 18.67mA instead of 20mA, thereby indicating a count of 11. When this occurs, the process equipment rejects the carton and resets the SLS part count in preparation for the next carton.

Parts Counting *(continued)*

Use the following steps to configure the SLS for the *Parts Counting: Teach* and *Parts Counting: Run* functions.

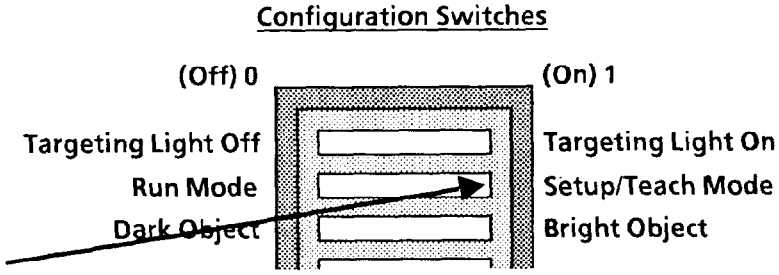
Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW4 must be *off* to enable the *1-D Spatial Measurement* function.



Set these "mode" switches as required for your application.

Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

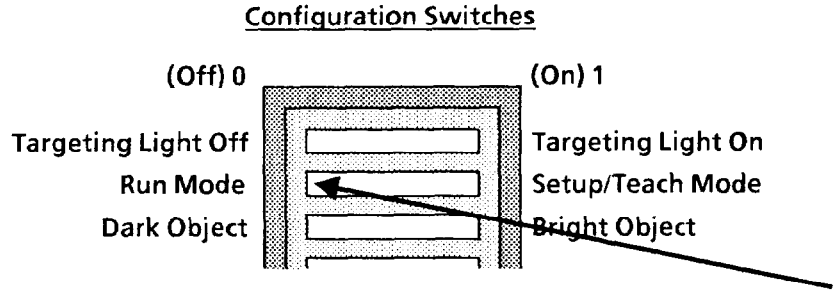
Set the operating mode switch to Setup/Teach Mode.



The SLS "learns" the lighting compensation and other parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the lighting compensation and parameters.

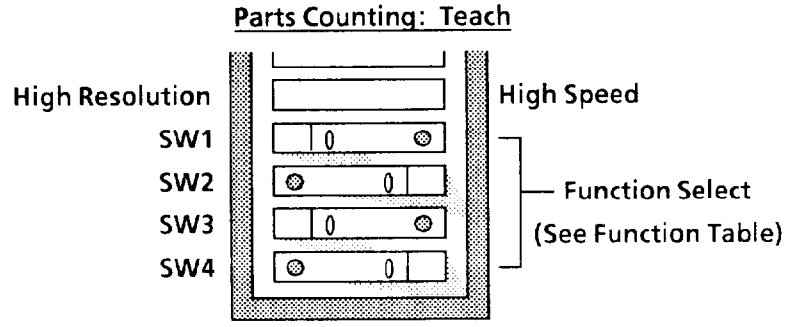
After a few seconds (or 10 to 20 image acquisitions), set the switch to Run Mode.

The SLS saves the lighting compensation parameters.

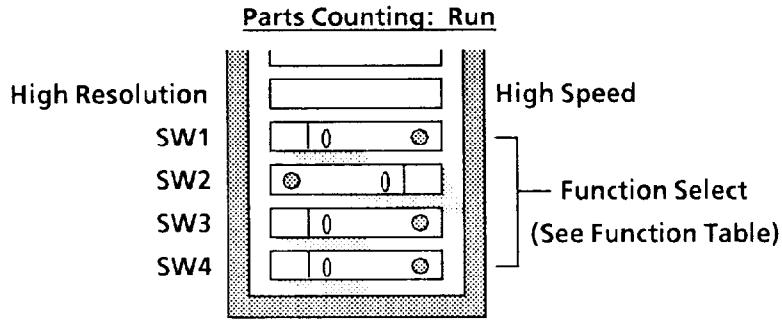


Parts Counting (continued)

Your Action	Comments
Remove the "ideal" object from the FOV.	
Set the lower four function switches as shown.	SW1 and SW3 must be *on* and SW2 and SW4 must be *off* to enable the *Parts Counting: Teach* function.



Set the trigger mode switch as required for your application.	**NOTE:** If your conveyor system moves at a *variable rate*, set the trigger mode switch to *Edge Triggered*, and *synchronize* the triggers to the conveyor system speed.
Pass the "ideal" object across the FOV first.	The SLS counts the ideal object and learns its *size*. During the *Parts Counting: Run* function, the SLS counts *only* those objects whose size is within ±50% of the ideal object's size.
Pass the remaining objects across the FOV.	The SLS learns the *maximum* number of objects to be counted during the *Parts Counting: Run* function. *Be sure that each object passes completely across the FOV, single file.* **NOTE:** Since the *spacing* of the image acquisitions must be the same during the Teach function as during the Run function, you should move the objects using either the actual conveyor system or a device that can simulate the conveyor rate.
When all objects have crossed the FOV, set the lower four function switches as shown.	SW1, SW3, and SW4 must be *on* and SW2 must be *off* to enable the *Parts Counting: Run* function.



The SLS is now ready to begin counting objects and sending the results to the analog and discrete outputs.

2-D Object Size

This analysis function enables the SLS to evaluate the two-dimensional size of an object moving across the FOV by comparing its size with the size of a "learned" *ideal* object stored in the SLS memory.

Two function switch settings are required: One is for teaching the object-size parameters, and the other is for performing the actual object measurement.

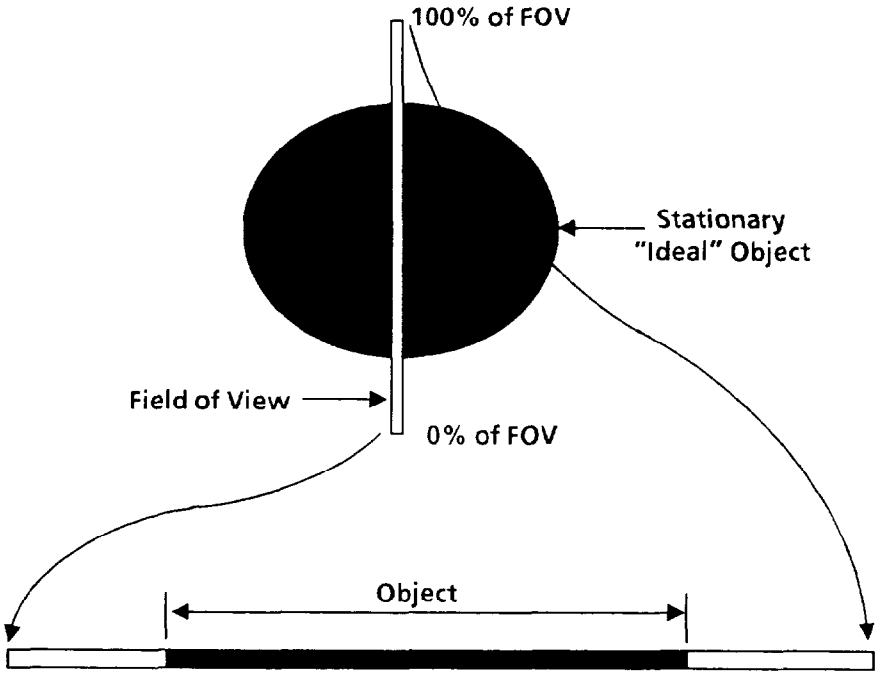
During the *2-D Object Size: Teach* function, the SLS "learns" the size of an "ideal" object by acquiring multiple images as the object moves across the FOV at right angles. The Analog A output remains a 4mA until the object has crossed the FOV; then, it indicates 50% of the full scale. The Analog B output indicates the object's width at the instant of each image acquisition; thus, it is likely to change as the object moves across the FOV.

During the *2-D Object Size: Run* function, when an inspected object moves across the FOV, the SLS calculates the object size, then calculates the value to be placed on the Analog A output using the following formula:

$$\text{Analog Output A} = \frac{\text{Measured Object Size}}{2 \times (\text{Taught Object Size})}$$

The Analog B output is the same as during the Teach function.

Before the SLS learns the object size parameters, it must learn lighting compensation parameters using the *1-D Spatial Measurement* function. With the ideal object positioned in the FOV as shown in the illustration below, and the operating mode switch set to "setup/teach," the SLS learns the lighting compensation parameters within a few seconds (10 to 20 image acquisitions).



2-D Object Size (continued)

When the operating mode switch is set to "run," the SLS *saves* the lighting compensation parameters in its memory.

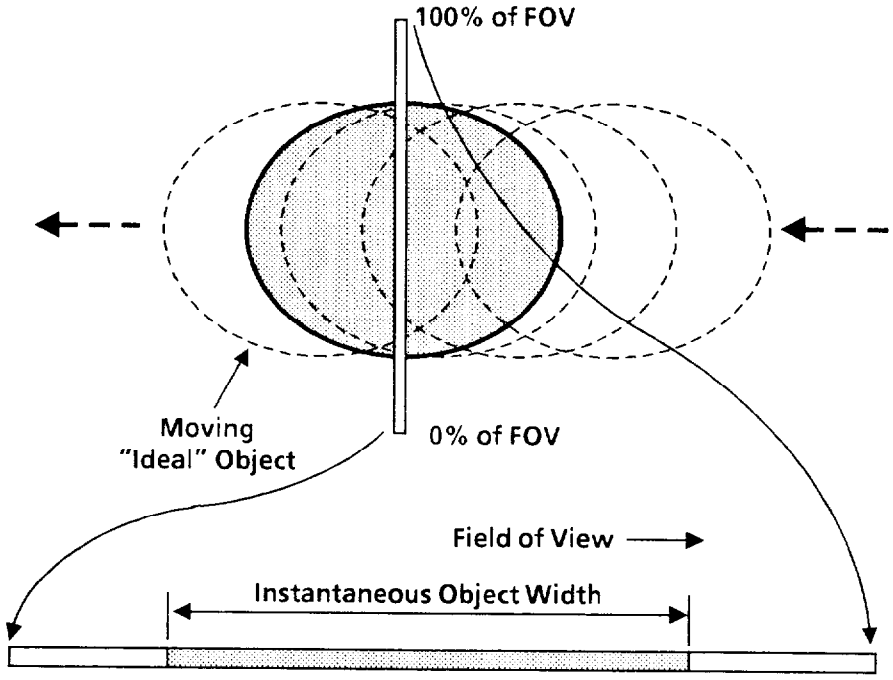
The analysis function switches are then changed to the *2-D Object Size: Teach* function, and the ideal object removed from the FOV.

Teach Function – The *2-D Object Size: Teach* function is a separate function-switch setting whose purpose is to enable the SLS to "learn" the size of the "ideal" object.

NOTE: During the Teach function, the *spacing* of the image acquisitions must be consistent.

Thus, if the conveyor moves at an *unvarying* speed, the SLS trigger mode switch can be set to *Level Triggered*, which enables the SLS to acquire images at its maximum rate. If the conveyor speed *varies*, however, the trigger mode switch should be set to *Edge Triggered* and the trigger signals synchronized with the conveyor.

The illustration below shows the movement of the "ideal" object as it crosses the FOV during the Teach function.



After the object passes the FOV, the SLS learns its size and records it at 50% of its *actual* size. This enables the SLS to accept size variations of ±50% from the size of the ideal object.

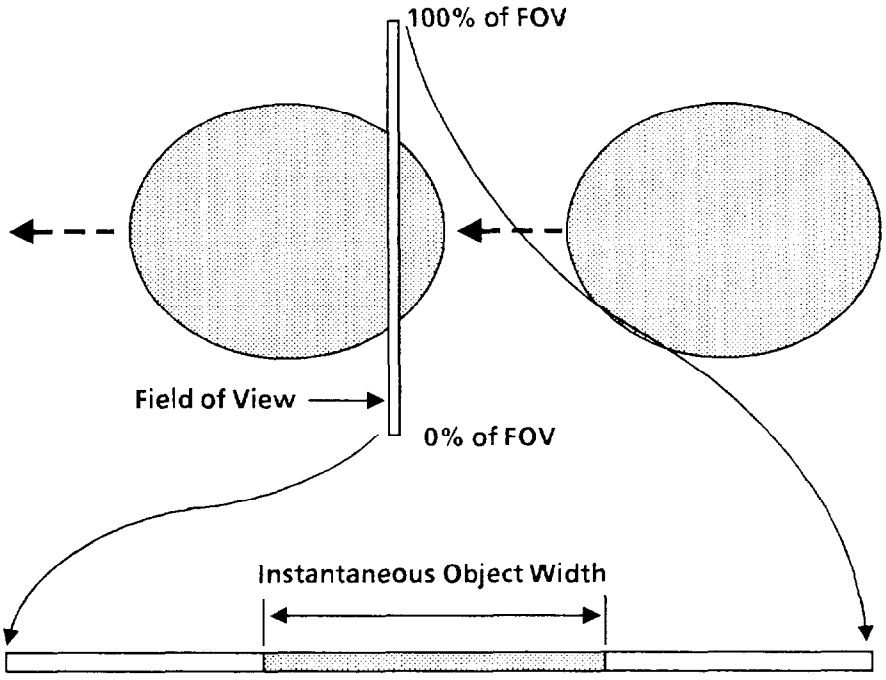
2-D Object Size *(continued)*

The Teach function is complete when the "ideal" object has passed completely across the FOV. At this point, you must set the function switches to the *2-D Object Size: Run* function.

Run Function– The *2-D Object Size: Run* function is a separate function-switch setting whose purpose is to enable the SLS to measure objects crossing the FOV by comparing them to the "ideal" reference object stored in memory.

During the Run function, the SLS compares the size of each object crossing the FOV with the size of the reference object. The SLS indicates the "result" as a *percentage of match to the reference object, divided by two.* Thus, a "perfect" match would be 50% for an object exactly the size of the reference object. This allows for measuring objects that are larger (as well as smaller) than the reference object.

The following illustration shows you how the SLS performs the Run function.

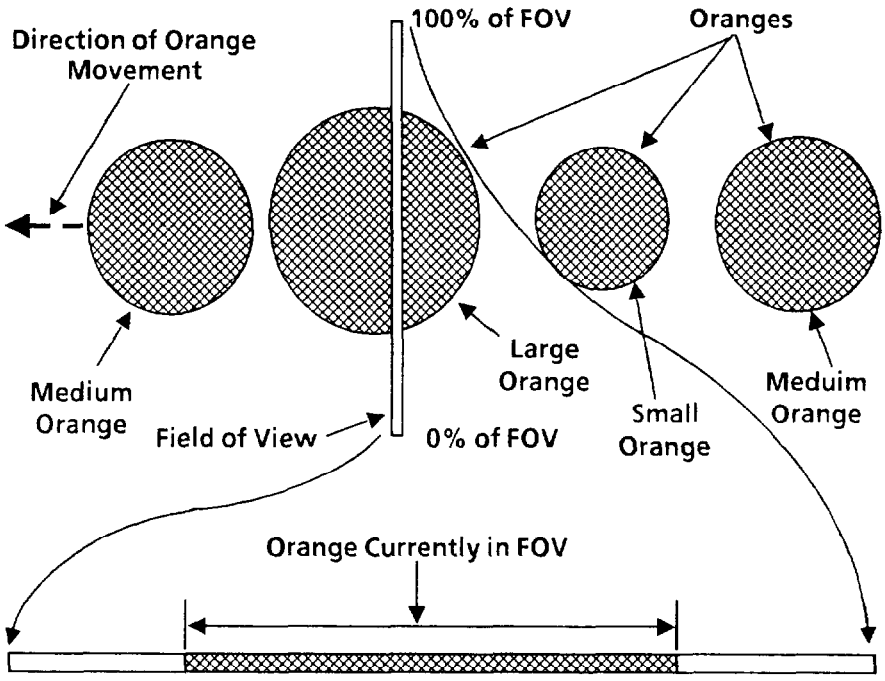


NOTE: *All* objects must cross the FOV *single file*, and they must be spaced far enough apart for the SLS to acquire at least *one* image in the gap between objects *at the applicable rate of movement.*

The objects' rate of movement during the Run function must be the same as their rate during the Teach function, unless synchronized triggering is used, as mentioned earlier. Thus, if the SLS "learned" an oblong reference object along its short axis, the SLS can determine the object's size along the long axis so long as the image acquisition spacing remains the *same.*

2-D Object Size *(continued)*

Example: Here is an example of using the object size function to sort oranges. The objective is to determine the size of each orange and the appropriate size category.



During the Teach function, the SLS "learns" the size of the "reference" orange, which in this example is a medium-size orange.

During the Run function, the SLS examines each orange, one-at-a-time. Thus, when the *first* (medium-size) orange crosses the FOV, the percentage of match is 50%, indicating that this orange is the same size as the reference orange. Thus, the Analog A output current is 50% of the difference between 4mA and 20mA, or 12mA.

When the *second* (large-size) orange crosses the FOV, the percentage of match is 65%, indicating that this orange is larger than the reference orange. Thus, the current is 65% of the difference between 4mA and 20mA, or 14.4mA.

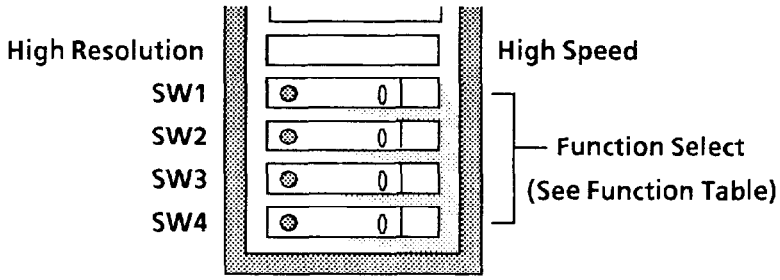
When the *third* (small-size) orange crosses the FOV, the result is a proportional *decrease* in current.

2-D Object Size (continued)

Use the following steps to configure the SLS for the *2-D Object Size: Teach* and *2-D Object Size: Run* functions.

Your Action	Comments
Set the lower four function switches as shown.	SW1 through SW4 must be *off* to enable the *1-D Spatial Measurement* function.

1-D Spatial Measurement

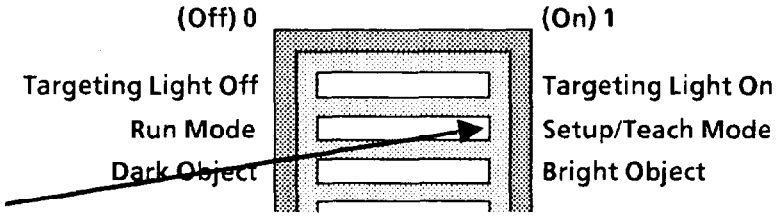


Set these "mode" switches as required for your application.

Object, trigger, lighting, remote configuration, outputs, and speed/resolution. Refer to Chapter 2 for information.

Set the operating mode switch to Setup/Teach Mode.

Configuration Switches

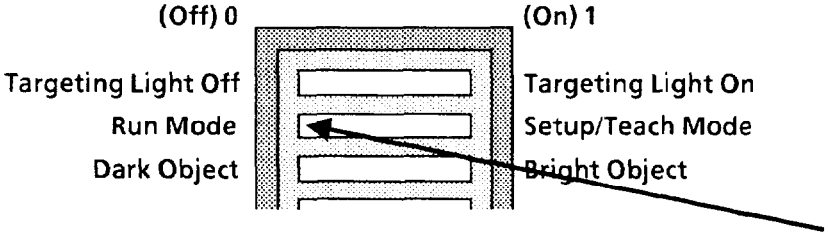


The SLS "learn" the lighting compensation parameters in a few seconds when the triggering mode switch is set to *Level Triggered* and the trigger input is *low*. When the switch is set to *Edge Triggered*, the SLS requires 10 to 20 image acquisitions (one for each high-to-low transition of the trigger signal) to learn the parameters.

After a few seconds (or 10 to 20 image acquisitions), set the switch to Run Mode.

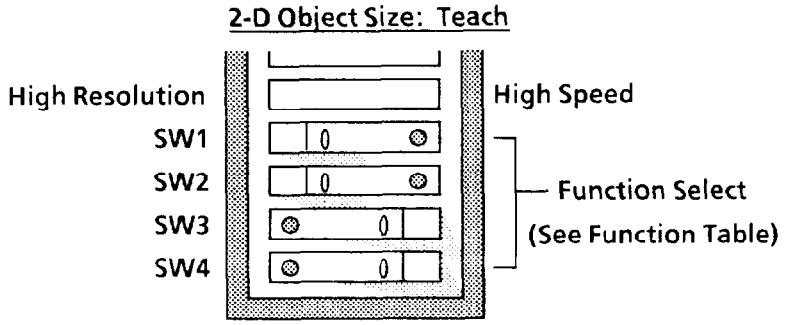
The SLS saves the lighting compensation parameters.

Configuration Switches

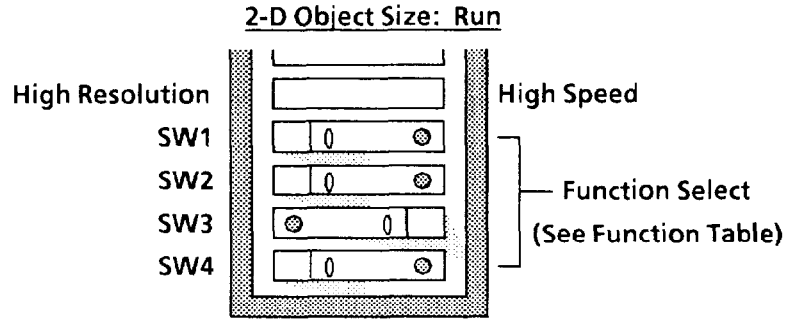


2-D Object Size (continued)

Your Action	Comments
Remove the "ideal" object from the FOV.	
Set the lower four function switches as shown.	SW1 and SW2 must be *on* and SW3 and SW4 must be *off* to enable the *2-D Object Size: Teach* function.



Set the trigger mode switch as required for your application.	**NOTE:** If your conveyor system moves at a *variable rate*, set the trigger mode switch to *Edge Triggered*, and *synchronize* the triggers to the conveyor system speed.
Pass the "ideal" object across the FOV.	The SLS learns the *size* of the ideal object. During the *2-D Object Size: Run* function, the SLS compares the size of all inspected objects with the size of the ideal object. **NOTE:** Since the *spacing* of the image acquisitions must be the same during the Teach function as during the Run function, you should move the objects using either the actual conveyor system or a device that can simulate the conveyor rate.
When the "ideal" object has crossed the FOV, set the lower four function switches as shown.	SW1, SW2, and SW4 must be *on* and SW3 must be *off* to enable the *2-D Object Size: Run* function.



The SLS is now ready to begin comparing inspected objects with its stored reference object and sending the results to the analog and discrete outputs.

Chapter 6 SLS Site Installation: Requirements and Procedures

Chapter Objective

The objective of this chapter is to describe the requirements and procedures for installing the SLS at its permanent operating site.

Site Preparation Requirements

Four site preparation tasks must be completed before you install the SLS:

- *AC Power* – If necessary, install an AC power source near the DC power supply. Be certain that the AC voltage is within the range that the power supply requires.
- *DC Power* – Prepare a mounting platform or surface for the DC power supply. Keep in mind that the power supply must be mounted within reach of the cable between the power supply and the SLS (20-foot maximum when using standard Brad-Harrison cables).
- *Mounting Fixtures* – Prepare all required fixtures, platforms, and/or surfaces for mounting the SLS and light source. Plan the field of view (FOV) and the relative mounting position for the SLS. (The SLS mounting bracket is compatible with Unistrut® mounting techniques.)
- *Cables* – Prepare a path for the SLS cable(s). Plan to route the cables as far away as practicable from moving machinery, excessive heat, and strong RF emissions.

Staging and Installation Procedures

In general, the SLS must be positioned so that it "sees" the inspected objects properly according to the application's requirements. The light source must be positioned to provide optimum contrast between the inspected objects and their background.

Staging involves measuring the required FOV and then determining the optimum positions for the SLS and light source *relative to the objects to be inspected.*

Installation involves securing the SLS and light source in their optimum positions and connecting the SLS to the power supply and the production equipment.

Determining FOV Width

The FOV width is primarily a function of the width of the objects to be inspected. For most analysis functions, the FOV must be wide enough to include the inspected objects, yet allow for some object shifting and/or width variations.

For analysis functions that require the inspected objects to lie completely *within* the FOV, measure the object's width, then add 20% to allow for object shifting and/or width variation. This will be the FOV width for your application.

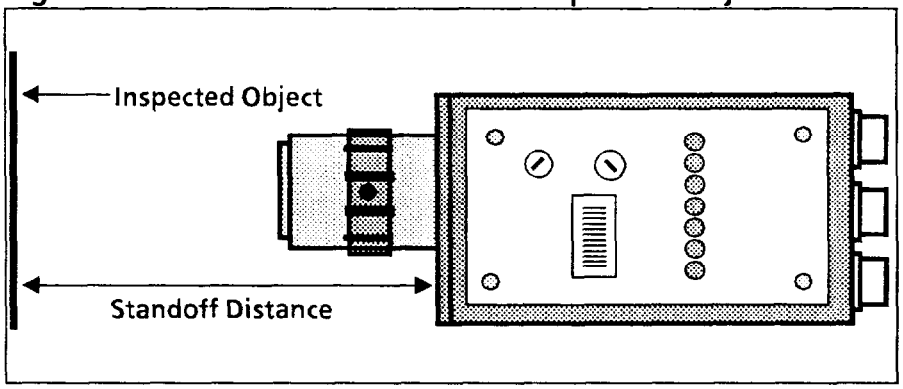
Determining FOV Width (continued)

For analysis functions that require only one edge of an object (*1-D Spatial Measurement*) or a portion of the object (*Full Field Texture Recognition*), place the SLS as close as practicable to the inspected objects in order to maximize the image resolution, yet provide an FOV that is wide enough to accommodate any anticipated shift in the object's position.

Focusing SLS

Focusing the SLS includes two main steps: measuring the standoff distance (the distance from the inspected object to the front plate of the SLS lens, as shown in Figure 6.1), and setting the focusing ring.

Figure 6.1 Standoff Distance From Inspected Object



Using the FOV width for your application, refer to Table 6.1 to find the corresponding standoff distance for the standard lens (2804-NL1) or wide angle lens (2804-NL2).

Table 6.1 Standoff Distance Determination

FOV Width vs Standoff Distance					
FOV Width Inches (mm)	Standoff Distance Inches (mm)		FOV Width Inches (mm)	Standoff Distance Inches (mm)	
	Standard Lens (2804-NL1)	Wide-Angle Lens (2804-NL2)		Standard Lens (2804-NL1)	Wide-Angle Lens (2804-NL2)
1.5(38.1)	6.8(173)	–	10(254)	27.6(702)	21.6(550)
2 (51)	7.9(201)	–	11(279)	30.1(765)	23.6(599)
3 (76)	10.3(261)	8.3(211)	20(508)	52.6(1337)	41.0(1040)
4(102)	12.7(323)	10.2(258)	30(762)	77.6(1972)	60.3(1532)
5(127)	15.2(386)	12.1(306)	40(1016)	102.6(2606)	79.6(2022)
6(152)	17.7(449)	14.0(355)	50(1270)	127.7(3242)	99.0(2515)
7(178)	20.1(512)	15.9(403)	60(1524)	153.0(3880)	118.3(3005)
8(203)	22.6(575)	17.8(452)	70(1778)	178.0(4516)	137.7(3498)
9(229)	25.1(638)	19.7(501)	–	–	–

Focusing SLS (continued)

For an FOV width lying *between* those listed in the table, use interpolation to determine the corresponding standoff distance.

Using the calibrated markings on the SLS lens, set the lens to the apropriate standoff distance. Use the set screw to lock the lens at that setting.

Positioning Ideal Object in FOV

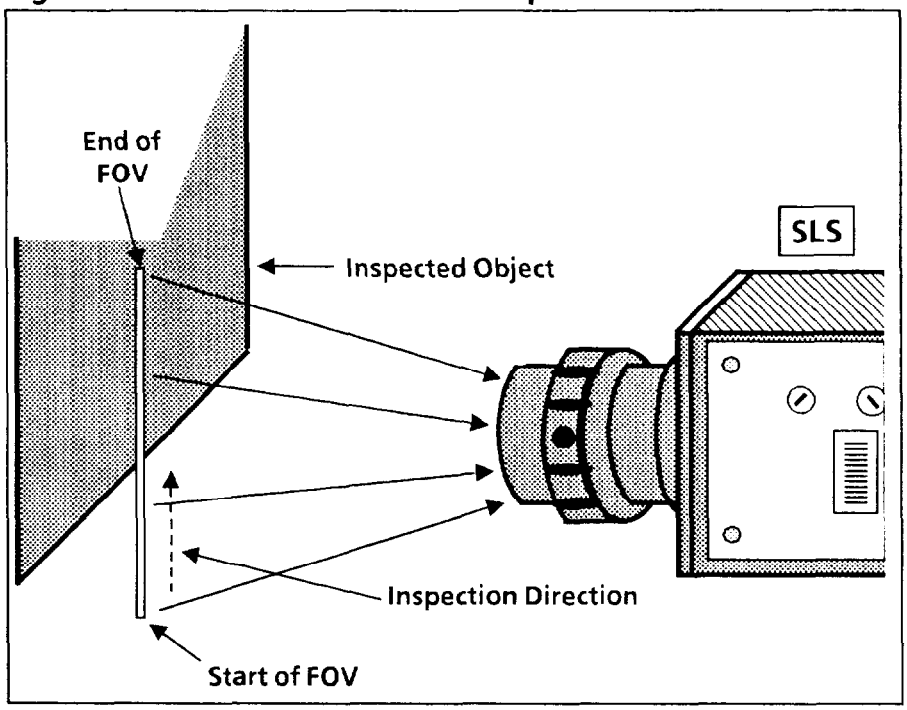
Manually position an "ideal" object exactly where it should be when the SLS acquires an image.

Secure the object in that position.

Mounting and Positioning SLS

Note that the SLS inspects an object starting from one end of the FOV and stopping at the other end. In effect, the inspection begins at the "bottom" and ends at the "top" of the SLS when it is positioned as shown in Figure 6.2.

Figure 6.2 FOV Orientation and Inspection Direction



With most analysis functions, you must take the inspection direction into account. For example, if your application requires using the 1-D Spatial Measurement function to locate the *first* edge of a dark object against a light background, and the dark object extends beyond the FOV, you must position the SLS so that the *start* of the inspection is in the light background area. Figure 6.2 shows this.

Mounting and Positioning SLS (continued)

Assuming that you have prepared all the necessary fixtures and/or mounting surfaces for the SLS, mount the SLS, but do not completely tighten the fasteners at this point. (Refer to the *Mounting Brackets* section in Appendix B for information about the Allen-Bradley mounting brackets.)

Aim the SLS so that the FOV lies approximately across the object as required for your application. Tighten the fasteners lightly at this point. You will be "fine-tuning" the aim later.

Mounting and Positioning Light Source

Assuming that you have prepared all the necessary fixtures and/or mounting surfaces for the light source, mount the light source, but do not completely tighten the fasteners at this point.

Turn on the lamp and aim it at the inspected object in the FOV. Adjust the light source so that it illuminates the object uniformly and produces good contrast between the object and its background. When you have optimized the object's illumination, tighten the fasteners.

SLS Connection Procedures

Connection involves connecting the J1, J2, and J3 cables, as required, between the SLS and the power supply and process equipment. Note that *all* SLS applications require the J1 cable, since it carries DC power to the SLS.

Connecting J1 Cable

The J1 cable carries DC power to the SLS, and also carries the strobe trigger output and the analog A and B outputs. Table 6.2 lists the specifications for those output signals:

Table 6.2 J1 Specifications: Strobe and Analog Outputs

J1 Signal	Specifications
Strobe Trigger Output	Strobe trigger signal (pin 5): Red wire with black tracer. Signal return (through the DC power common, pin 3): Green wire. Active state: + 5V (typical); inactive state: 0V. Current is limited to 9mA. Compatible with all Allen-Bradley strobe light sources. Output is not isolated.
Analog A and B Outputs	Analog A output signal (pin 2): Red wire. Analog B output signal (pin 4): Red wire with yellow tracer. Signal return (through the DC power common, pin 3): Green wire. High-side sourcing 4-20mA. Maximum load resistance: 500 Ohms.

Connecting J1 Cable (continued)

Chapter 3 showed you how to connect the AC and DC power cables to their respective terminal blocks on the 2801-P3 or 2801-P4 power supply. Use that same information to make power connections to the power supply and SLS at their permanent location, if you have not already done so.

If your application requires the analog B output, connect the analog B output wire and common return wire to your process equipment.

If your application requires the analog A output, connect the analog A output wire and common return wire to your process equipment.

If your application requires a strobe light source, connect the strobe trigger output wire to the strobe trigger input signal. Connect the common return to the strobe trigger return signal.

Connecting J2 Cable

The J2 cable carries the trigger input signal and return, and the discrete A and B outputs. Table 6.3 lists the specifications for those input and output signals:

Table 6.3 J2 Specifications: Trigger Input and Discrete Outputs

J2 Signal	Specifications
Trigger Input	Trigger signal (pin 1): Red wire with white tracer. Signal return (pin 3): Green wire. Voltage level: + 5V to + 30VDC. Output isolation from other I/O: 300 V. Maximum source off-state leakage: 1mA. Response time for triggered image acquisition: 75µS maximum.
Discrete Outputs	Discrete A output signal (pin 4): Red wire with yellow tracer. Discrete B output signal (pin 5): Red wire with black tracer. Signal return (pin 3): Green wire. 30VDC or 30VAC (max. peak); Class 2 supply* Maximum current: 100mA. Isolation from other I/O: 300V. Polarity insensitive.

*A NEMA/NEC Class 2 power-limited-type supply should be used for both control and I/O power to preserve internal transient and overload protection functions of SLS.

If your application requires the trigger input, connect the trigger signal input wire and trigger signal return wire to your process equipment.

Connecting J2 Cable

If your application requires the discrete A output, connect the discrete A output wire and common return wire to your process equipment.

If your application requires the discrete B output, connect the discrete B output wire and common return wire to your process equipment.

Connecting J3 Cable

The J3 cable carries the RS-232 data input and output signals and signal return. Table 6.4 lists the specifications for those input and output signals:

Table 6.4 J3 Specifications: RS-232 Data I/O and +24VDC Output

J3 Signal	Specifications
RS-232 Serial I/O	Transmit data signal (pin 1): Red wire with black tracer. Receive data signal (pin 2): Red wire with white tracer. Common return (pin 4): Green wire. Serial I/O is used with Allen-Bradley 2804-SW1 Configuration Support Software only.

If your application requires *only* the RS-232 serial I/O, use the special 12-foot J3 cable supplied with the SLS Configuration Support Software package. This cable has a 25-pin D-type connector already attached. You can order it separately as Catalog No. 2804-CSC1.

Before Applying AC Power

Before applying AC power to the power supply, be sure that the source voltage lies within the range appropriate for the power supply.

Refer to the instruction sheet supplied with the power supply for specific ratings and requirements.

Performing Powerup Check

Refer to Chapter 3 and perform the SLS powerup check as described.

Fine Tuning SLS Aim

You can use both the targeting light and the analog outputs to "fine tune" the SLS aim so that the FOV lies across the inspected objects exactly where it is required.

Check the position of the "ideal" object in the image area. It should be in the *optimum* position for your intended application.

Turn off any light source that you are using to illuminate the inspected objects. If the image field is still quite bright because of high ambient light, you may need to shield it before performing the next step.

Set the targeting light switch to *on*, and aim the SLS so that the line of light (that is, the FOV) lies across the object as required for your application.

NOTE: After being turned on for two minutes, the light will automatically turn off to avoid overheating. To turn the light on again, wait a few moments to allow the light to cool. Turn the switch to *off*, then *on* again.

Tighten the SLS mounting fasteners, then turn off the targeting light.

Turn the light source on again.

To verify the aim using the analog outputs, configure the SLS for 1-D Spatial Measurement by operating the SLS in the "setup/teach" mode for a few seconds, then operating in the run mode. Use the appropriate triggering and object "color" mode.

Connect the analog A output line to an accurate milliammeter and look at the reading. The reading will show you exactly where the edge of the object is in the FOV.

Example: Assume that your application requires a 6-inch FOV, and the first edge of the object must be 1.5 inches from the start of the FOV. You will use the analog A output to determine the position of the first edge along the FOV.

The analog A reading at the *start* of the FOV is always 4mA, and the reading at the *end* of the FOV is always 20mA; thus, the range across the FOV is always 16mA.

Since the first edge position in this example must be 1.5 inches from the start of the FOV, using the following formula,

$$\text{Output (mA)} = \left(\frac{\text{Output \%}}{100\ \%} \times 16\text{mA} \right) + 4\text{mA}$$

the meter will indicate a reading that corresponds to the 25% of FOV point.

Thus, the meter should read 8mA if the first edge is *exactly* where it should be. If it isn't, you can reposition the SLS until the reading is exactly 8mA, then tighten the mounting fasteners.

Table 6.1 Standoff Distance Determination

FOV Width vs Standoff Distance					
FOV Width Inches (mm)	Standoff Distance Inches (mm)		FOV Width Inches (mm)	Standoff Distance Inches (mm)	
	Standard Lens (2804-NL1)	Wide-Angle Lens (2804-NL2)		Standard Lens (2804-NL1)	Wide-Angle Lens (2804-NL2)
2 (51)	7.9(201)	–	11(279)	30.2(767)	23.6(599)
3 (76)	10.3(262)	8.3(211)	20(508)	52.7(1339)	41.0(1041)
4(102)	12.7(323)	10.2(259)	30(762)	77.6(1971)	60.3(1532)
5(127)	15.2(386)	12.1(307)	40(1016)	102.6(2606)	79.6(2022)
6(152)	17.7(450)	14.0(356)	50(1270)	–	126.3(3208)
7(178)	20.1(511)	15.9(404)	60(1524)	–	118.3(3005)
8(203)	22.6(574)	17.8(452)	70(1778)	–	137.7(3498)
9(229)	25.1(638)	19.7(500)	80(2032)	–	–
10(254)	27.6(701)	21.6(549)	90(2286)	–	–

Appendix A Definition of Terms

Appendix Objective

The objective of this appendix is to define briefly some terms used in this manual that have a special meaning for machine vision and/or the SLS.

Definition of Terms

Access Panel – The access panel is the means by which you, the user, interact with the SLS while configuring the SLS. The panel contains as set of 12 switches in a dual inline pack (DIP), seven LEDs, and two setpoint controls.

Analog Outputs – The SLS has two analog outputs, A and B, that correspond to the discrete A and B outputs.

These lines carry inspection results to your production equipment in the form of a current that can vary from 4mA to 20mA.

The level of the analog current corresponds to either a percentage of the field of view or a percentage of match to a reference image stored in the SLS memory. In either case, 4mA represents 0%, and 20mA represents 100%.

Analysis Function – This is one of the eight inspection operations for which the SLS can be configured.

An analysis function is selected by the specific settings of four switches on a 12-switch DIP on the SLS access panel.

Discrete Outputs – The SLS has two switched outputs, A and B, that correspond to the analog A and B outputs.

These outputs carry "two-state" inspection results to your production equipment; that is, they are either "open" or "closed," according to the specific inspection results, the setting of the *Output N.O./Output N.C.* function switch, and the setting of the corresponding setpoint control.

Edge – Within the SLS field of view, an edge is the location of a significant transition from light to dark or dark to light. Most of the SLS analysis functions determine edge locations as part of their overall inspection objective.

Field of View (FOV) – The FOV is what the linear (one-dimensional) sensor in the SLS "sees." Compared to the FOV of a two-dimensional sensor, which has both length *and* width, the linear sensor's FOV is a thin line – its has only *length*.

The length of the FOV is a function of the *lens* (standard or wide angle) and the *distance* from the lens front plate to the inspected object. Increasing distance increases the length of the FOV. For any given distance, a wide angle lens results in a longer FOV than a standard lens.

In practice, the SLS must be physically oriented so that the FOV, which is parallel to the bracket mounting surface, lies *across* the inspected object at the correct point for the intended inspection, measurement, or comparison.

Definition of Terms (continued)

Gray Scale Image – The linear sensor in the SLS "sees" an inspected object in varying shades of gray.

Image Resolution – Image resolution indicates the ability of the SLS to resolve the edge position of an object in the FOV. The actual values, rated in terms of percent of FOV, can be seen in Table B.1 in Appendix B. These values pertain to results expected from a high-contrast object and nearly ideal lighting conditions.

Inspection Results; Results – These terms refer to the consequences of an SLS inspection, measurement, or comparison as indicated by the condition of the discrete outputs and the level of current in the analog outputs.

Learn Function – The Learn function is the *first* of the two switch selections required when configuring the SLS for the parts counting or two-dimensional object analysis function. (The second switch selection is the Run function.)

When performing the *Parts Counting: Learn* function, the SLS learns the object width and the maximum number of objects to be counted.

When performing the *2-D Object Size: Learn* function, the SLS learns the object size in two dimensions.

Lighting Compensation – Lighting compensation is an automatic function that enables the SLS, while operating in the setup/teach mode, to adjust to the light level within the image field. The SLS can adjust to wide range of light levels.

SLS – This is the abbreviation for Smart Linear Sensor. The SLS is a linear machine vision system in which the lens, linear sensor, and image-processing electronics are all contained in a single NEMA-4X housing.

Object; Inspected Object – These terms refer to any item that the SLS inspects, measures, or compares.

Reference Object; Ideal Object – These terms refer to an object whose image the SLS stores in its memory ("learns") for use with those analysis functions that perform comparisons.

Run Function – The Run function is the *second* of the two switch selections required when configuring the SLS for the parts counting or two-dimensional object analysis function. (The first switch selection is the Learn function.)

When performing the *Parts Counting: Run* function, the SLS compares the size of each object it inspects to the size of the stored reference object, then counts the number of objects having the correct size.

When performing the *2-D Object Size: Run* function, the SLS compares the size of each inspected object to the size of the stored reference object, then reports the percentage of match to the reference object.

Definition of Terms (continued)

Run Mode – When the *Run Mode, Setup/Teach Mode* switch is set to the run mode, the SLS inspects, measures, or compares the inspected object according to the selected analysis function.

Setup/Teach Mode – When the *Run Mode, Setup/Teach Mode* switch is set to the setup/teach mode, the SLS accumulates lighting compensation and other parameters. This step is required for all analysis functions before operating the SLS in the run mode.

Standoff Distance – Standoff distance is the distance from the inspected object to the front plate of the SLS lens. This is the distance used to focus the SLS lens.

Trigger Source – The trigger source is the point of origin of the signal that starts an inspection cycle while the SLS operates in either the setup/teach mode or the run mode.

The trigger source depends on the setting of the *Level Triggered, Edge Triggered* switch on the SLS.

When the set to the level triggered mode, the SLS uses its internal trigger *so long as* the trigger input is either *high* or *open*. If so, the SLS operates at the maximum rate for the selected analysis function. If the trigger input is *low*, SLS operation is inhibited.

When the set to the edge triggered mode, the SLS requires an external trigger. The SLS performs one inspection cycle with each falling edge (high to low) of the trigger signal, up to the maximum rate for the particular analysis function. The external trigger rate is dictated by events at the presence sensing switch or other source.

Appendix B Reference Information

Appendix Objective

The objective of this appendix is to provide easy access to specific information and procedures under alphabetically arranged topic headings.

Using Appendix B

Information and procedures in this appendix appear under the following topic headings:

- Focusing the SLS.
- Exposure time, cycle time and lighting compensation.
- Speed vs resolution.
- The side-view SLS: 2804-SLS2.
- Lens filter maintenance and replacement.
- I/O connections.
- Mounting brackets.
- Trigger input modes.
- Binarization and background light probe.
- Burst acquisition mode.
- Set point methods; invert discrete output B.
- Disable lighting compensation.
- Covers on J2 and J3 connectors.
- Power loss recovery.
- Grounding.

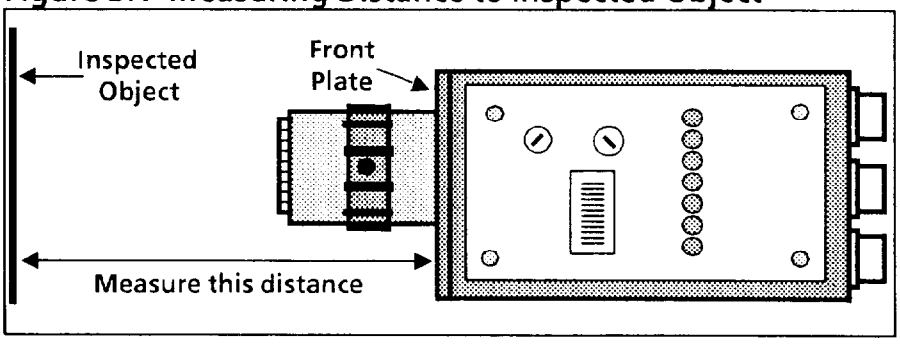
Focusing SLS

Use these three steps to focus the SLS:

1. Measure the distance to the inspected object.
2. Set the focusing ring.
3. Lock the focusing ring.

Step 1: Measure the distance between the front plate of the lens assembly to the inspected object, as shown in Figure B.1, below.

Figure B.1 Measuring Distance to Inspected Object

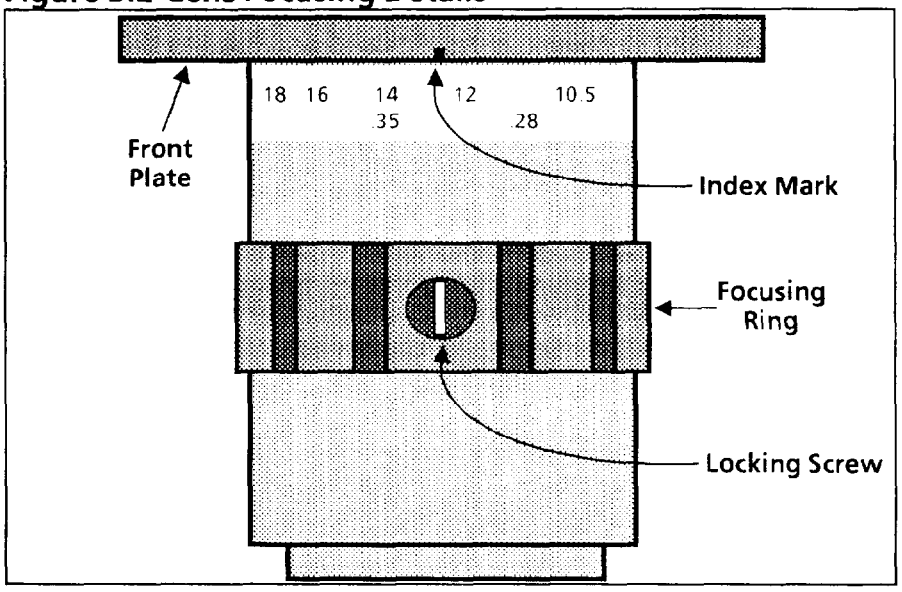


Focusing SLS (continued)

Step 2: Loosen the three locking screws on the focusing ring until the ring turns freely. Then, turn the ring until the front plate-to-object distance that you measured in Step 1 is aligned with the index mark on the front plate.

For example, if your measured distance is 13 inches (0.33M), set the focus ring so that the index mark is about halfway between 14 and 12, as shown in Figure B.2, below:

Figure B.2 Lens Focusing Details



Step 3: Lock the focusing ring by carefully tightening one of the three locking screws. Use a small screwdriver such as the one supplied with the SLS. *Do not over tighten.*

Exposure Time, Cycle Time, and Lighting Compensation

Exposure time is the period during which the linear sensor element in the SLS accumulates light from the image area, including the inspected object. Exposure time is measured in milliseconds, and it starts with the triggering event and ends when the SLS "acquires" the image data.

During operation in the setup/teach mode, the SLS uses the light from the image area to compute or "learn" the *lighting compensation* parameters. The SLS stores these parameters when it enters the run mode.

During operation in the run mode, the SLS uses the stored lighting compensation parameters to compute the proper exposure time.

If the light intensity in the image area changes, the SLS changes the exposure time accordingly. Thus, if the light intensity *increases*, the SLS *decreases* the exposure time, and vice versa. The SLS can vary the exposure time from 0.5mSec to 200mSec (the limits of the lighting compensation function).

Exposure Time, Cycle Time, and Lighting Compensation (continued)

Cycle time is the minimum interval, in milliseconds, that the SLS requires before it can respond to the next trigger signal. It includes exposure time, image acquisition time, image processing time, and lighting compensation computation time.

Cycle time also reflects the *maximum* triggering rate. Thus, for a cycle time of 20mSec., the maximum triggering rate is 50 triggers per second.

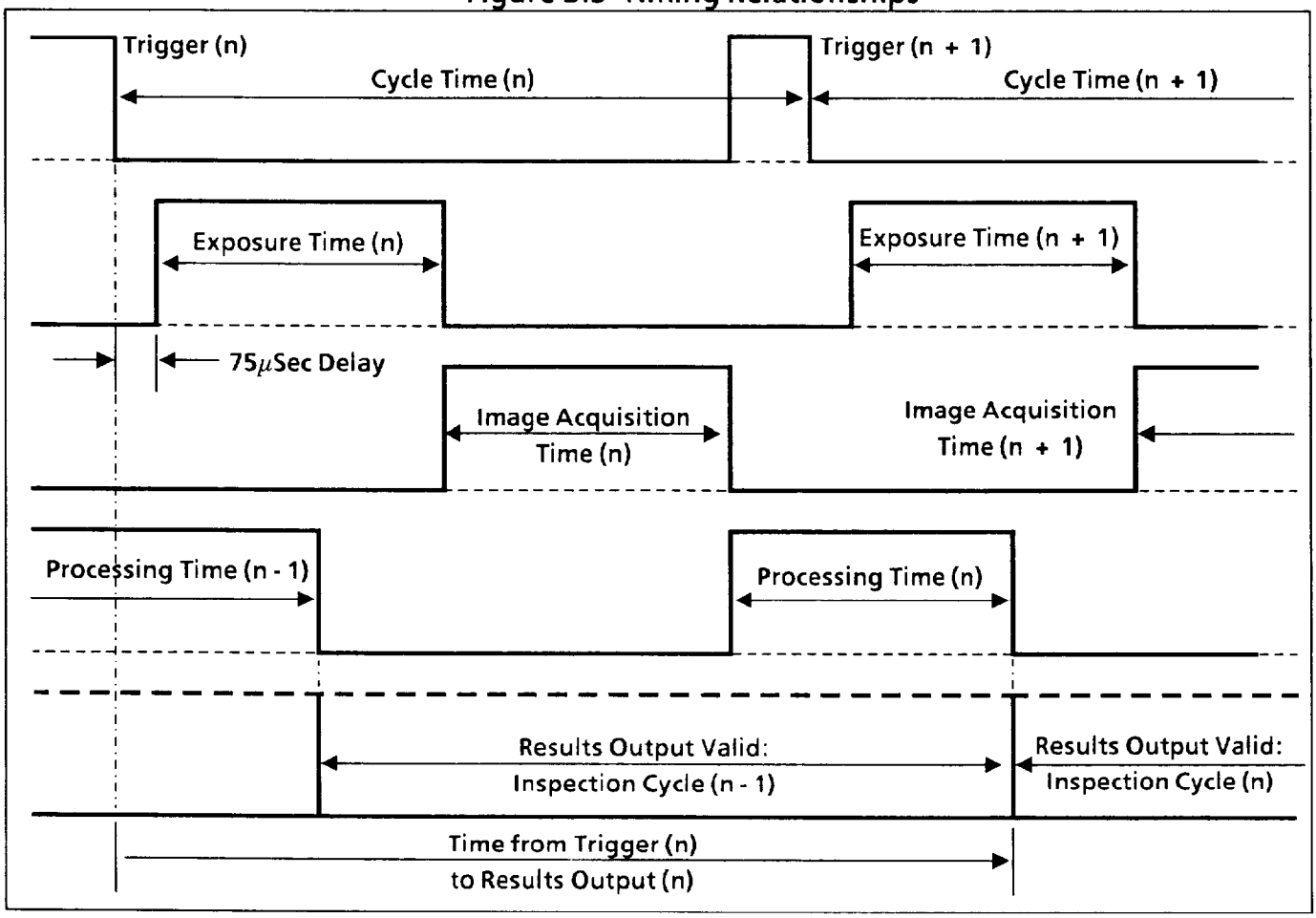
Increased exposure time can increase the minimum ("base") cycle time of an analysis function. The cycle time increases in steps as the exposure time increases. For example, a base cycle of 20mSec. increases to 25mSec. when the exposure time passes 16mSec.

The Brightness LED turns solid red just *before* the cycle time increases above the base value. It indicates that the present light intensity may *not* be sufficient to maintain the cycle time at its base value.

If the base cycle time is not required for a particular application, the increased exposure time may not affect the application. The *maximum* exposure time, however, is 200mSec., as noted earlier.

Figure B.3 indicates the basic timing relationships.

Figure B.3 Timing Relationships


Trigger (n)
Cycle Time (n)
Trigger (n + 1)
Cycle Time (n + 1)
Exposure Time (n)
Exposure Time (n + 1)
75μSec Delay
Image Acquisition Time (n)
Image Acquisition Time (n + 1)
Processing Time (n - 1)
Processing Time (n)
Results Output Valid: Inspection Cycle (n - 1)
Results Output Valid: Inspection Cycle (n)
Time from Trigger (n) to Results Output (n)

Speed vs Resolution

When you select the *High Speed* mode or *High Resolution* mode, your choice affects the resolution and accuracy of the SLS and the cycle time of the selected analysis function. In general, *high resolution* increases both the resolution and accuracy, but requires a longer cycle time than *high speed.* Also, the more complex functions require longer cycle times.

Table B.1 lists these effects for each analysis function.

Table B.1 High Resolution vs High Speed Mode: Resolution, Accuracy, and Base Cycle Time

Analysis Function	High Resolution			High Speed		
	Resolution (% of FOV)	Accuracy (% of FOV)	Base Cycle Time	Resolution (% of FOV)	Accuracy (% of FOV)	Base Cycle Time
1-D Spatial Measurement	0.125%	0.25%	25ms	0.250%	0.50%	20ms
Object Width Measurement	0.125%	0.25%	25ms	0.250%	0.50%	20ms
Object Void Measurement	0.125%	0.25%	30ms	0.250%	0.50%	20ms
*Largest Object Width	0.125%	0.25%	30ms	0.250%	0.50%	20ms
1-D Object Recognition	0.125%	0.25%	40ms	0.250%	0.50%	30ms
Included-Object Texture Recognition	0.125%	0.25%	40ms	0.250%	0.50%	30ms
Full-Field Texture Recognition	NA	NA	25ms	NA	NA	20ms
*Binary Object Size	0.125%	0.25%	20ms	0.250%	0.50%	15ms
*Binary Object Count	0.125%	0.25%	20ms	0.250%	0.50%	15ms
Parts Counting: Teach	NA	NA	30ms	NA	NA	25ms
Parts Counting: Run	NA	NA	30ms	NA	NA	25ms
2-D Object Size: Teach	0.125%	0.25%	30ms	0.250%	0.50%	25ms
2-D Object Size: Run	0.125%	0.25%	30ms	0.250%	0.50%	25ms

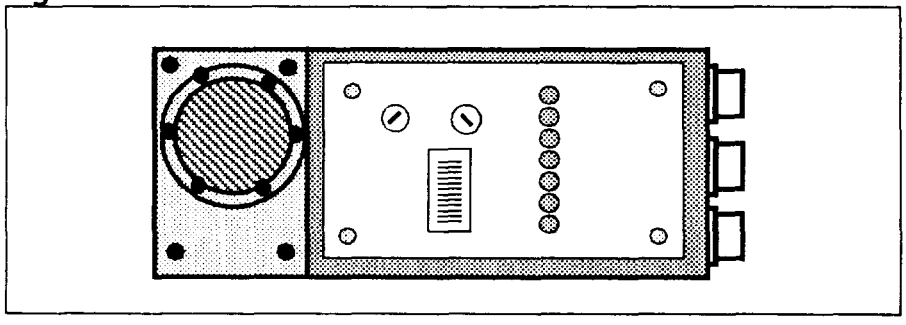
*Series B SLS only. Binary functions require connecting the SLS to a personal computer using the SLS Configuration Support Software.

Side-View SLS: 2804-SLS2

The side-view SLS is intended for inspection applications where space limitations prevent using the front-view SLS.

As Figure B.4 shows, the lens is on the same side as the access panel.

Figure B.4 Side-View SLS: 2804-SLS2

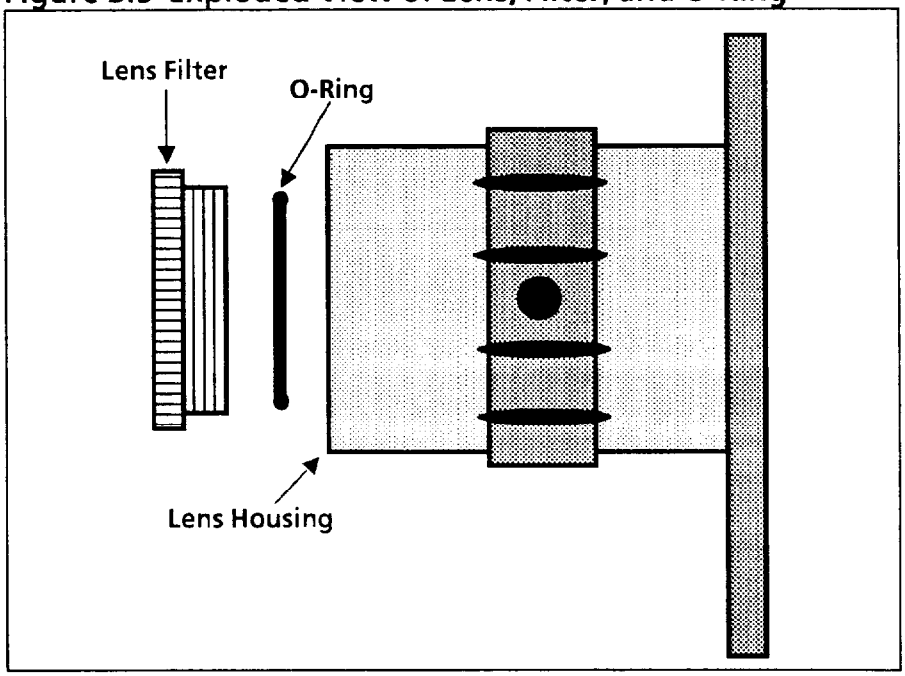


Lens Filter: Maintenance and Replacement

The lens filter has two functions: It protects the lens, and it seals the SLS against moisture and dirt.

As Figure B.5 shows, the filter is threaded, and can be removed for cleaning or replacement.

Figure B.5 Exploded View of Lens, Filter, and O-Ring



You should clean the filter periodically, especially in dirty environments. The filter is made of polycarbonate plastic; however, use care when handling and cleaning it to avoid finger prints and scratches.

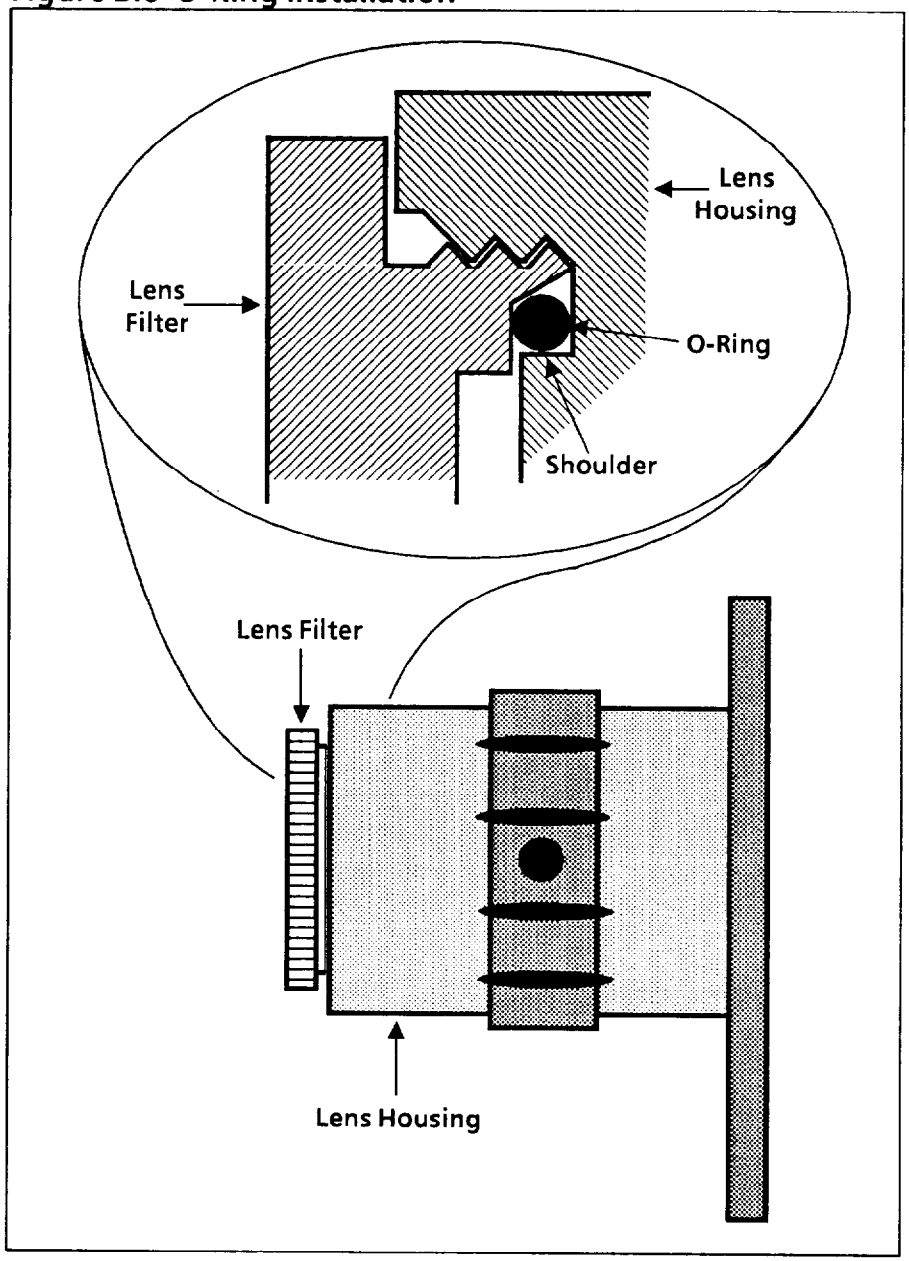
To clean the filter, use a soft, lint-free tissue dampened with glass cleaner. If the filter appears excessively scratched, replace it with a new one.

You can obtain a package of ten new filters from your local Allen-Bradley distributor, using Catalog No. 2804-FL1.

CAUTION: The O-ring is used to seal the lens housing and maintain the NEMA-4X rating. When you replace the filter, be sure to install the O-ring around the "shoulder" in the lens housing, as shown in Figure B.6, *not* on the filter. If you attempt to mount the O-ring on the filter, it may be damaged when you screw the filter into the lens housing.

Lens Filter: Replacement and Maintenance (continued)

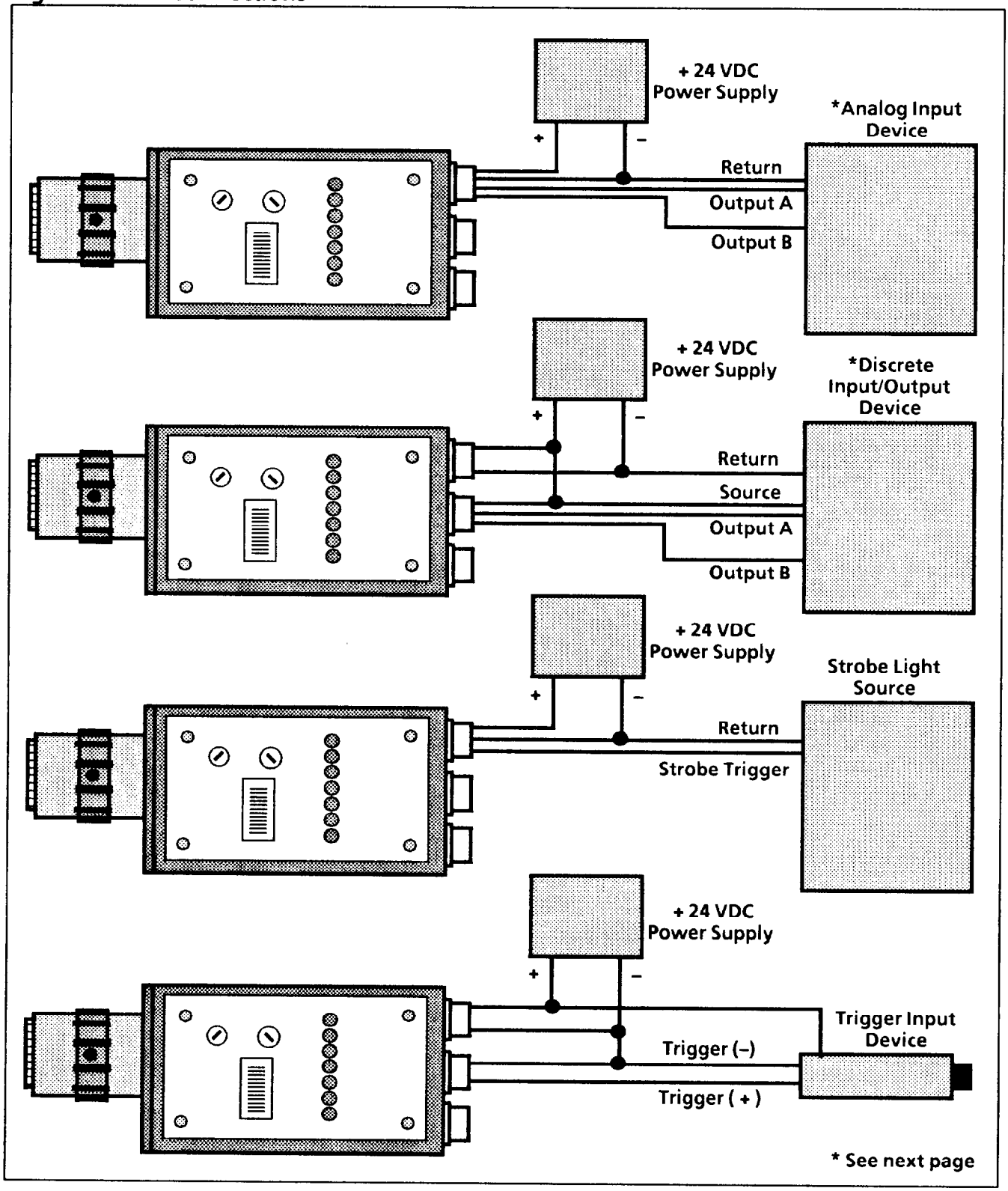
Figure B.6 O-Ring Installation



I/O Connections

Figure B.7 shows the SLS connected to the various input and output devices.

Figure B.7 I/O Connections



I/O Connections (continued)

The following analog and discrete input modules are available from Allen-Bradley and are recommended for use with the SLS:

Discrete input modules:

- Catalog No. 1771-IB, IBD, IBN, IQ, IT, IV, and IVN.

Analog input modules:

- Catalog No. 1771-IE, IFE, IF, and IL.

Installation and connection procedures for these modules are beyond the scope of this manual. Refer to the instruction and/or data sheets included with each module for specific connection and installation information.

Mounting Brackets

Allen-Bradley supplies two types of brackets for mounting the SLS: A stainless steel bracket, Catalog No. 2804-BR1, and an aluminum bracket, Bulletin 880-N12. The 2804-BR1 provides an extra axis of motion, and is required to maintain the NEMA-4X rating.

Both the SLS and the mounting brackets are shipped with #10 - 32 screws that are suitable for mounting the bracket to the SLS. Full dimension details are provided in the instruction sheet shipped with the SLS.

CAUTION: When mounting the bracket to the SLS, observe the following cautions:

1. Do not exceed 30 inch-pounds of torque, ±10%, when tightening the bracket mounting screws. Otherwise, the screw inserts in the SLS case may pull out and destroy the case or cause it to leak.
2. Do not exceed 11 foot-pounds of torque, ±10%, when tightening the 5/16 - 18 friction pivot bolt on the 2804-BR1 mounting bracket.
3. If you use other means to mount the SLS, do not use mounting screws that are long enough to strike the bottom of the screw inserts.

Trigger Input Modes

The SLS provides two trigger input modes: Level triggering, and edge triggering. One of these is selected during the configuration operation.

Level triggering requires the trigger input to be either *high* (+5 VDC to +30 VDC) or *low* (0 VDC). When the input is high, the SLS cannot acquire images. When the input is low, the SLS acquires images at the *maximum rate*, using an internal trigger. The maximum rate is determined by the inspection cycle time, which depends on the analysis function in use and the exposure time.

Trigger Input Modes (continued)

Edge triggering requires the trigger input to transition from *high* (+5 VDC to +30 VDC) to *low* (0 VDC). When this occurs, the SLS acquires one image. The *maximum* trigger repetition rate is determined by the inspection cycle time, which depends on the analysis function in use and the exposure time.

Binary Threshold Background Light Probe

When an SLS (Series B only) is connected to a personal computer using the Series B SLS Configuration Support Software (CSS), the *Binary Object Size* and *Binary Object Count* analysis functions are available. Both functions require setting a binary threshold, using the CSS View Image option, in order to determine the point above which the SLS can detect objects in the FOV. The SLS ignores or "masks off" all objects in the FOV that are *below* the selected binary threshold. (For more information, refer to the SLS Configuration Software Support User's Manual, Catalog No. 2804-ND002 Series B.)

The binary threshold can be fixed or "absolute," and remain at the same value regardless of background light level changes, or it can be "light-compensated," and change its value according to background light level changes detected by the background light probe.

Both the binary threshold level and the background light probe can be adjusted, as required, in the View Image display option. Once adjusted, their values can be stored in a configuration record for later use.

Burst Acquisition Mode

When an SLS (Series B only) is connected to a personal computer using the Series B SLS Configuration Support Software (CSS), the SLS can be configured to use the "burst acquisition mode" with any analysis function. The burst acquisition mode can be enabled and configured *only* within a configuration record. Also, since the timing of the analog and discrete outputs is indeterminate when using the burst mode, only the RS-232 results should be used. (For more information, refer to the SLS Configuration Software Support User's Manual, Catalog No. 2804-ND002 Series B.)

Using the burst acquisition mode, the SLS can acquire *and store* a rapid succession or "burst" of images before processing any of them. This capability can be useful when a series of images must be acquired more rapidly than the normal cycle time for the specified analysis function allows.

For example, if an application required a series of four images, spaced at 10ms intervals, but the normal cycle time for an object width measurement were 25ms, then 25ms is the *minimum* time that the SLS requires between trigger signals. Using the burst acquisition mode, however, the SLS can be configured to acquire from 2 to 9 images, at intervals ranging from 6ms to 25ms.

Burst Acquisition Mode *(continued)*

The burst acquisition mode can be configured using one of the following two methods:

1. Using *one* trigger to acquire a specified number of images (2 to 9) having a specified interval (6ms to 25ms) between them, *or*

2. Using *multiple* triggers to acquire a specified number of images (2 to 9). (The interval must be specified as "0.")

In the second method, the SLS evaluates the time interval between the first and second triggers and uses that as the baseline for the intervals between the remaining triggers.

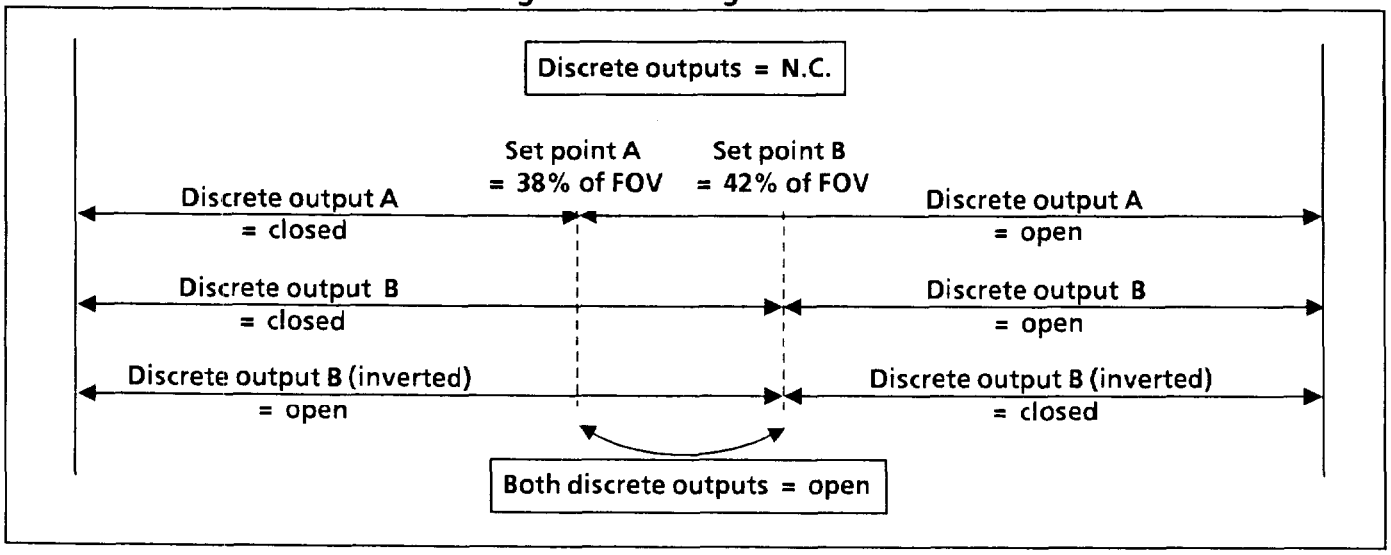
For example, if the SLS expects seven triggers, but the interval between trigger #3 and trigger #4 exceeds twice the interval between triggers #1 and #2, the SLS assumes that a missed trigger has occurred. It then "times out," processes the images already acquired (#1, #2, and #3), sends the results data to the PC, and resets the burst count.

Set Point Methods

When an SLS (Series B only) is connected to a personal computer using the SLS Configuration Support Software (CSS), the SLS can be configured to enable both set points (A *and* B) to operate on the same inspection result; that is, both can operate on output A *or* output B. This has the effect of setting two range limits for one result, such as object width.

For example, assume that output A indicates an object width, and the desired width is represented by 40% at output A, with the lower range limit being 38% and the upper range limit being 42%. With set point A set to 38%, set point B set to 42%, the "Outputs N.O./Outputs N.C." switch set to "N.C.," and the Invert Output B option selected, both discrete outputs are open *only* between 38% and 42%. Above or below that range, one or the other discrete output is closed. This is shown in the following figure:

Figure B.8 Using Both Set Points on One Result



Invert Discrete Output B

When an SLS (Series B only) is connected to a personal computer using the SLS Configuration Support Software (CSS), the SLS can be configured to invert the output from discrete output B. This function can be used as described in the discussion of *Set Point Methods*. Thus, when the discrete output would normally be open (because of the setting of the *Outputs N.O./Outputs N.C.* switch), inverting the output causes it to be closed.

Disable Lighting Compensation

When an SLS (Series B only) is connected to a personal computer using the SLS Configuration Support Software (CSS), the SLS can be configured to disable the automatic lighting compensation function in order to accommodate special lighting situations, such as backlighting.

Generally, you would first *enable* the lighting compensation long enough to permit it to adjust to the existing luminance level, then disable it to prevent further automatic adjustments from occurring when intended (or unintended) changes occur in the background luminance level.

One example is to disable lighting compensation when using bright backlighting, so that the background luminance reaches saturation. This intensifies the contrast between the object and the background, and enhances the edge detection capability of the SLS.

Another example is to disable lighting compensation in order to accommodate objects with reflections or bright areas that are either brighter than the background (for a dark object with a light background), or are brighter than the object (for a light object with a dark background). In either case, disabling the lighting compensation maximizes the contrast between the object and the background, and enhances the edge detenction capability of the SLS.

Power Loss Recovery

The SLS contains an electrically eraseable, read only memory (EEPROM) for storing "learned" configuration data. This data transfers to the EEPROM when you change the operating mode switch from "setup/teach" to "run." The transfer requires two to three seconds, maximum.

If a power loss occurs *immediately* after you set the operating mode switch to "run," the configuration data may not transfer correctly to the EEPROM. Subsequently, when power is restored, the LEDs may indicate an "EEPROM checksum failure." You can correct this condition by resetting the switch to "setup/teach" and enabling the SLS to relearn the configuration data.

Power Loss Recovery (continued)

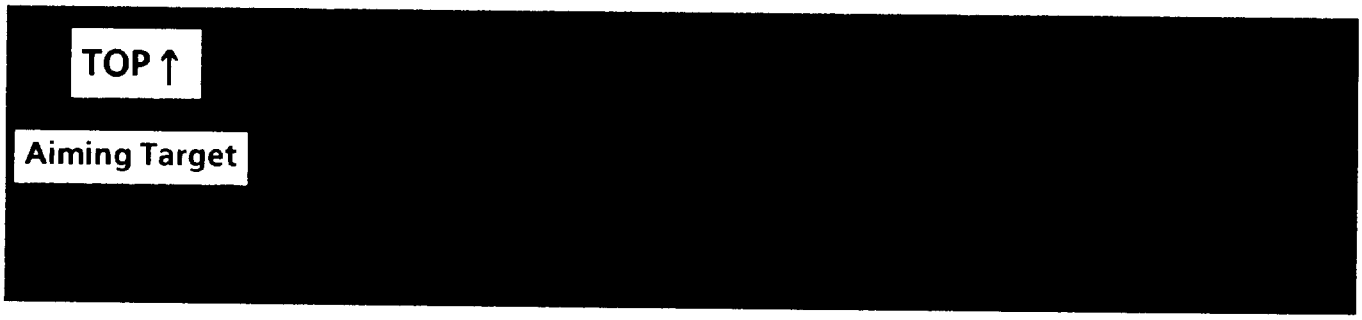
If a power loss occurs while the SLS is operating in the run mode, the configuration data *remains* in the EEPROM. Thus, after power is restored,the SLS can continue its inspection operations without relearning the configuration data. However, you may have to restart your process in order to re-synchronize it with the SLS..

Connector Covers on J2 and J3

The SLS is shipped with metal access covers on SLS connectors J2 and J3. Be sure to leave these covers in place if your application does not require using J2 and/or J3. When these connectors are not used, the covers must be installed to maintain the NEMA-4X rating by sealing the SLS, maintain ESD (electrostatic discharge) isolation, and protect the unused connectors.

Grounding

The AC power source(s) must all be properly grounded in accordance with applicable local codes. For information about of wiring and grounding for your SLS system, refer to the Allen-Bradley publication *Grounding and Wiring Guidelines*, Publication No. 1777-4.1.


TOP ↑
Aiming Target

ALLEN-BRADLEY
A ROCKWELL INTERNATIONAL COMPANY

A subsidiary of Rockwell International, one of the world's largest technology companies, Allen-Bradley meets today's automation challenges with over 85 years of practical plant floor experience. More than 12,000 employees throughout the world design, manufacture and apply a wide range of control and automation products and supporting services to help our customers continuously improve quality, productivity and time to market. These products and services not only control individual machines, but also integrate the manufacturing process while providing access to vital plant floor data that can be used to support decision-making throughout the enterprise.

With offices in major cities worldwide.

WORLD HEADQUARTERS
Allen-Bradley
1201 South Second Street
Milwaukee, WI 53204 USA
Tel: (414)382-2000
Telex: 43 11 016
FAX: (414)382-4444

EUROPE/MIDDLE EAST/ AFRICA HEADQUARTERS
Allen-Bradley Europe B.V.
Amsterdamseweg 15.
1422 AC Uithoorn
The Netherlands
Tel: (31)2975/43500
Telex: (844) 18042
FAX: (31)2975/60222

ASIA/PACIFIC HEADQUARTERS
Allen-Bradley (Hong Kong) Limited
Room 1006, Block B, Sea View Estate
2-8 Watson Road
Hong Kong
Tel: (852)/887-4788
Telex: (780) 64347
FAX: (852)/510-9436

CANADA HEADQUARTERS
Allen-Bradley Canada Limited
135 Dundas Street
Cambridge, Ontario N1R 5X1
Canada
Tel: (519)623-1810
FAX: (519)623-8930

LATIN AMERICA HEADQUARTERS
Allen-Bradley
1201 South Second Street
Milwaukee, WI 53204 USA
Tel: (414)382-2000
Telex: 43 11 016
FAX: (414)382-2400

Catalog No. 2804-ND001 Series B

40062-209-01(B)